Striking a Balance

Managing Collaborative Multitasking in Computer-supported Cooperation

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Striking a Balance – Managing Collaborative Multitasking in Computer-supported Cooperation.

Abstract

This thesis is a collection of six papers and a cover paper reporting an exploration of how to strike a balance between individual task execution and work articulation in Computer-supported Cooperative Work (CSCW). The interest in this theme is motivated by an increased reliance of IT-supported cooperative work arrangements in modern organizations, the fragmented layout of work for multitasking individuals and reports on various forms of overload, increased level of stress and anxiety experienced by workers active in these organizations.

Modern organizations are increasingly reliant on IT-supported cooperative work arrangements for doing work. Cooperators are not only expected to execute assigned tasks, but also to engage in work articulation. This is a term used to describe the process of rich and frequent interaction needed for securing that the contributions of cooperators are executed in such a way that the overall goal is reached. As cooperators typically are involved in several work formations in parallel, they need to find a balance between individual work and work articulation in relation to several work formations. The challenge of finding a balance in cooperative work has only to a limited extent been addressed in CSCW and there are few successful designs available for this purpose. The scope of this thesis is to develop an understanding of the challenges faced and strategies deployed by cooperators and work formations for striking a balance in work. The purpose is therefore to *explore how multitasking individuals manage to find a balance between task execution and articulation work in computer-supported cooperative work, what challenges they face in the process, and how IT should be designed to support them*. To reach this purpose several instances of cooperative work in different contexts have been closely studied.

The main conclusions of this thesis are that cooperators are constantly struggling for a balance in work through making frequent switches between work formations, individual task execution and work articulation, sometimes through making switches in the technology that is used. Strategies for finding this balance are developed in relation to the specific context of a cooperative activity as cooperators 'design' their use of IT, structures, procedures and norms. It is further concluded that for avoiding overloads of interaction, cooperators show and estimate availability through reliance on various sources of shared information, that social (e.g. interpersonal relation) and contextual factors (e.g. location) are considered when establishing interaction, that cooperators when searching for interaction with others are influenced by their estimated availability, competence and willingness to assist, but also by network maintenance efforts (i.e. an ambition to avoid overloading and underutilizing other cooperators). Finally, it is concluded that norms are important for finding a balance in work as they reduce the interaction needed for work articulation.

The main contributions of this thesis are rich descriptions of four cooperative work formations, the challenges they face and the strategies they apply, redefined theoretical concepts (i.e. availability management, interruption, multitasking) and extended understanding of interaction search behavior and ways to achieve high levels of informal interaction across distance. This work also provides some practical contributions in the form of implications for designers of supportive IT and implications for cooperators active in modern organizations.

Keywords
Computer-supported Cooperative Work, articulation work, individual task execution, balance, interruptions, availability, awareness, interaction, information technology, multitasking, task switching.

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My office, a cold and rainy day in November 2009
Rikard

Preface

This thesis that addresses challenges faced and strategies deployed when striving for balance in computer-supported cooperation is a collection of six papers and a cover paper. The collection of papers is placed directly after the cover paper. These are the papers that are included in the thesis:

(1). Harr, R. (2002). Exploring the Concept of Group Interaction Through Action in a Mobile Context. In *Proceedings of the 13th International Conference on Database and Expert Systems Applications* (Aix-en-Provence, France, Sept. 02-06, 2002). London, UK: Springer-Verlag, pp. 567–576.

(2). Harr, R., and Wiberg, M. (2008). Lost in Translation: Investigating the Ambiguity of Availability Cues in an Online Media Space. *Behaviour & Information Technology*, vol. 27 (3), pp. 243–262.

(3) Scholl, J., McCarthy, J., and Harr, R. (2006). A Comparison of Chat and Audio in Media Rich Environments. In *Proceedings of the 2006 20th Anniversary Conference on Computer-supported Cooperative Work* (Banff, Alberta, Canada, Nov. 04-08, 2006). New York: ACM Press, pp. 323-332.

(4) Harr, R., and Kaptelinin, V. (2007). Unpacking the Social Dimension of External Interruptions. In *Proceedings of the 2007 International ACM Conference on Supporting Group Work* (Sanibel Island, FL, Nov. 04-07, 2007). New York: ACM Press, pp. 399-408.

(5) Harr, R., Wiberg, M., and Whittaker, S. (Submitted to journal). The Survival of the Social: Social Interaction Foraging in Highly Distributed Professional Social Networks.

(6) Harr, R., and Kaptelinin, V. (2009). Being Virtually Everywhere: An Exploration of Teachers' Multitasking in a Hybrid Ecology of Collaboration. In *Proceedings of the European Conference on Cognitive Ergonomics* (Otaniemi, Helsinki, Finland, Sept. 30–October 2, 2009). Finland: VTT, pp. 307-314.

Contents

Chapter 1
Introduction

It is something of a platitude to say that the majority of work in modern organizations is done not by sole individuals, but by socially organized constellations of interdependent professionals. These arrangements, where participants are often distributed across distance, are highly dependent on information technology (IT). Due to work interdependence, cooperators contribute by performing individual task execution but also have to take part in overhead efforts for meshing, interrelating, coordinating and adjusting their individual contributions to reach the goal of the activity. These efforts are fundamental for the overall outcome of the mutual project, especially when tasks faced are complex i.e. characterized by uncertainty and requiring constant adaptation. The overhead activities, sometimes referred to as articulation work, are to a large extent managed through rich, extensive, and often informal and computer-mediated interaction. For individuals taking part in several of these work projects, the amount of informa-

tion sharing and interaction could be overwhelming. For organizations and individuals it is fundamental to find ways to enable both individual task execution and articulation of these efforts. Interesting issues are at stake, the purpose is therefore *to explore how multitasking individuals manage to find a balance between task execution and articulation work in computer-supported cooperative work, what challenges they face in the process, and how IT should be designed to support them.*

To place this purpose into context it is necessary to provide a background regarding the factors that have created the problem area explored in this thesis.

In recent decades, modern organizations and corporations have increasingly come to rely on more flexible and interdependent structures for doing work. These arrangements that, among other things, promote dynamic communication structures have proven to be efficient for achieving competitiveness (Johansen et al. 1991, Cataldo et al. 2006) and often consist of participants with complementing competencies from various organizations. There are several reasons for organizations' increased reliance on these constellations. Besides amplified competition, turbulence and uncertainty in organizational environments (Bannon 1993, Hinds and McGrath 2006, Schmidt 2006), there are also arguments for another reason, namely, increased complexity of the tasks, problems, and issues that organizations face (Nelson and Stolterman 2003, Hinds and McGrath 2006).

Any cooperative work arrangement faces two fundamental requirements: how to divide work into executable tasks, and how to coordinate work on these tasks to accomplish the overall goal (Mintzberg 1999). The way these requirements are managed is very much dependent on contextual factors and the type of task that is faced. In the dynamics of modern organizations, coordination of work through following pre-established procedures, schedules or schemas of task execution is no longer appropriate (Schmidt 2006). Instead, more flexible approaches are needed and in recent decades we have witnessed an increased reliance on structures better equipped to manage these dynamics of modern work settings (Van de Ven et al. 1976, Kraut et al. 1990a, Hutchins 1995, Mintzberg, 1999, Schmidt 2006). These structures promote mutual adaptation and dynamic responses (Fussel et al.

1996, Hinds and McGrath 2006) and are required to meet the challenges of new organizational contexts.

Coordinating cooperative work under these circumstances is indeed a challenge and the level of overhead work that is needed is substantial. Schmidt (2006, and Schmidt and Bannon 1992) uses the term *articulation work* (adopted from Strauss et al. 1985, Strauss 1985 and 1988, Gerson and Star 1986) to describe the overhead efforts needed to coordinate, integrate, keep in check and manage the activities of distributed and semi-autonomous individuals (Schmidt and Bannon 1992). Failing to do so has negative consequences for the quality of the overall outcome of the cooperative activity. In what follows, the term articulation work is used to describe the processes needed to 'link' individual contributions together in cooperative work. Even though articulation work does not directly contribute to the outcome of an activity, it needs to be undertaken as the quality of the outcome would be inferior if work were organized based on unrelated individual task execution (Schmidt 1990). The fact that individuals are semi-autonomous, i.e. partly independent of the work processes of others, makes them more flexible and enables fast responses to changing circumstances. It also means that, besides being distributed in time and space, cooperators are also distributed logically in terms of control. This comes naturally from the complementing roles, responsibilities, competencies, motives and strategies of cooperators (Schmidt and Bannon 1992). Even if cooperating individuals are autonomous to some extent, they are also reliant on the work of others. This brings a need for continuous work articulation, something that is managed through various forms of rich, extensive and often informal communication (Galbraith 1977, Katz and Tushman 1978, Kraut et al. 1990a, Schmidt and Bannon 1992, Mintzberg 1999).

Taking active part in a cooperative work arrangement where individual task execution and work articulation is tightly interwoven should be considered as a situation of *multitasking* (Su and Mark 2008). This is a concept used by researchers active in the field of Computer-supported Cooperative Work (CSCW) to describe situations in which individuals are working on several tasks in parallel or in an immediate series. As cooperators are involved in several cooperative formations running in parallel, they are often forced to make switches of tasks. This is what CSCW researchers call *task switching*. Adding to

the complexity of working in a modern organization, individuals typically take part in several cooperative work arrangements at the same time (Leroy and Sproull 2004, Gonzalez and Mark 2004). This creates a fragmented work situation where efforts needed for work articulation and individual task execution in relation to several instances of cooperative work are tightly integrated. If cooperators fail to deliver or finalize the tasks they have been assigned, the consequence will most likely be that the overall outcome will have unfinished components or parts. If work articulation fails, perhaps due to assigning too much effort to individual task execution, the result will probably be that the overall outcome suffers from incoherence. Both these failures could have devastating effects on organizations.

Taking active part in work articulation of a cooperative work project is associated with involvement in substantial amounts of interaction and managing vast amounts of information. When participating in several work projects the interaction load is multiplied. As support for articulating work, various mechanisms of interaction can be useful. These mechanisms may reduce the interaction needed for managing articulation work and consist of organizational structures (formal as well as informal), plans and schedules, standard operating procedures, and conceptual schemes (see Schmidt and Bannon 1992 for a more thorough review). Due to the complexity of the tasks that cooperative work formations face, these mechanisms themselves entail articulation work (Gerson and Star 1986, cited in Schmidt and Bannon 1992). The result is that work in a cooperative work arrangement is associated with substantial amounts of interaction, not only related to the content of an activity but also the form and mechanisms that are relied on.

One form of interaction that has received significant attention in previous CSCW research is *informal communication,* and its important for cooperative work has been extensively acknowledged (e.g. Kraut et al. 1990a, Whittaker et al 1994, Mintzberg 1999, Nardi et al. 2000, Jeffrey and McGrath 2000, Luo and Olson 2006). It has even been claimed that it is so crucial for the process of coordinating work that without it many collaborations would never occur, or break up before being successful (Kraut et al. 1990a). Even though formal interaction is not excluded in the current exploration, special emphasis is placed on informal interaction due to its focal aspects for the articulation of work. Informal communication has been somewhat loosely

defined as communication that is spontaneous, interactive and rich (Kraut et al. 1990a) and some of its main advantages for cooperative work arrangements are how it enables cooperators to tune into the progress of one another's work, monitor the overall group process, coordinate actions and solve problems together (Nardi et al. 2000, Kiesler and Cummings 2002). Taking the challenges associated with conducting cooperative work in modern organizations into consideration, it is evident that the communication form is of great importance. However, previous research has also shown that informal communication is generally mediated by physical proximity (e.g. Kraut et al. 1990a, Whittaker et al. 1994, Jeffrey and McGrath 2000, Kiesler and Cummings 2002). This is problematic for modern organizations as these rely to an increasing extent on work arrangements where organizational borders and geographical distances separate cooperators.

Alongside and also as part of this organizational change, IT has become a key component for organizational work and is now integrated into a broad range of organizational activities. Due to an increase in mobile technology and extensive computerization of our work settings, modern work is taking place in an environment characterized by connectivity "anytime, anyplace" (Kleinrock 1996). For cooperative work arrangements with their extensive need for work articulation, the radical increase of information and communication technology (ICT) such as mobile phones, email, instant messaging (IM), video calls, and chats have become of pivotal importance (Olson and Olson 2001, Kraut et al. 2006). For promoting informal communication across distance, Kraut and Attewell (1997) highlight the importance of email, while Nardi et al. (2000) speak in favor of IM for this specific purpose. Most attempts to support informal communication across distance have, however, relied on different forms of telecommunication systems such as the Media Space system (Bly et al. 1993), the Cruiser system (Fish et al. 1993), the OfficeWalker system (Obata and Sasaki 1998), and the Videowindow system (Fish et al. 1990a). These technologies, which often provide audio and video channels to users, commonly fail to encourage the same levels of informal interaction as in face-to-face settings (e.g. Kraut et al. 1990a) and often increase work fragmentation and levels of interruption for their users (Fish et al. 1993, Tang and Rua 1994).

Indications of challenges associated with the modern work arrangement started to appear more than a decade ago and reports are still being produced about how new work forms, multitasking and increased use of IT are causing fresh challenges for individuals, groups and organizations. The downside of the new work situation, with its technological characteristic of connectivity 'anytime, anyplace', has been identified by researchers arguing that the more information we receive, the more likely it is that we will experience situations that will have negative effects on our productivity and well-being (e.g. Dabbish and Kraut 2004). These reports describe instances of information overload (e.g., Schultze and Vandenbosch 1998, Farhoomand and Drury 2002, Janssen and de Poot 2006), interaction overload (Ljungberg and Sørensen 2000), email overload (e.g. Whittaker and Sidner 1996, Dabbish and Kraut 2006, Hancock et al. 2009) communication overflow (Ljungberg 1996), or cognitive overload (Fussel et al. 1998) and are heard more often today than ever before. Other symptoms of the challenges faced in modern work environments are the advent of various forms of GTD (Getting Things Done) applications e.g. SimpleGTD[1] and ThinkingRock[2] for managing multitasking and work fragmentation (all designed on the principle put forward by Allen 2001) and the increased reliance on RSS (Really Simple Syndication) for getting updates and for reducing information search time.

As this challenging situation for cooperators active in modern organizations is at least partly caused by IT, it seems reasonable to believe that the foundation on which current IT-support for cooperative work is based requires further exploration.

To summarize this introduction, new organizational structures are relied on for getting work done in modern organizations. These structures consist of flexible constellations of semi-autonomous distributed individuals dependent on rich and frequent, often computer-mediated and informal, interaction for managing cooperative work. In combination with the fact that individuals work in multiple cooperative work arrangements in parallel, this creates a situation of work fragmentation, overload and stress, affecting individuals as well as organizations in a negative way. It is likely that IT designed without taking the mechanisms of collaborative multitasking into consideration is one of

[1] http://www.simplegtd.com/
[2] http://www.trgtd.com.au/index.php

the factors behind the current situation. With this background in mind it is time to move on to the aim of the thesis and the specific research questions that are explored.

1.1 Aim of the thesis

Computer-supported cooperative work involves articulation work and individual execution of tasks. The term articulation work (Strauss 1985, Strauss et al. 1985, Gerson and Star 1986, Strauss 1988) refers to the overhead efforts needed to manage mutual dependence between cooperators. These need to articulate (divide, allocate, coordinate, mesh, schedule, interrelate) their activities in order to know who is doing what, how, when, where, under which restrictions, and by means of what? (Schmidt 2006). As such, articulation work is "a kind of supra-type of work in any division of labor, done by various actors" (Strauss 1985, p. 8). According to Schmidt (2006) the term has several advantages in comparison to that of coordination. Articulation work is more flexible as it includes a lot more than scheduling and allocating resources. For example, it includes the processes through which cooperators monitor each other, resolve inconsistencies, mismatched assumptions and beliefs, etc. Further, articulation work refers to the needs of multiple cooperators and does not necessarily cover coordination of the interdependent activities of one actor. The term is also envisioned in relation to a specific context and the constrains that this context has for cooperative work, as well as it is conceived of as continuous articulation of work in the face of unforeseen events.

Individual task execution refers to the process by which work assigned through division of labor is executed. In real life, the relation between task execution and articulation is not that binary. Not only do individuals execute tasks, there are situations where two or more individuals are executing tasks together, or where a large work group is divided into several sub-groups with responsibilities for task execution. This thesis focuses specifically on individual task execution and does not cover other forms. In what follows, the terms individual work and task execution are used interchangeably to describe an individual working on a task assigned through division of labor, in order to avoid irritating repetition.

To strike a balance between work articulation and individual task execution means that cooperators take such an active part in articula-

tion of work that the quality of the outcome of the overall activity is secured. This means that they take such an active part in the overhead efforts that issues such as interrelating individual contribution in terms of quality and style, assigning responsibilities, defining problems and agreeing on usage of shared resources are solved. But at the same time cooperators also need to execute tasks assigned to them through division of labor with sufficient speed and quality. As work articulation is managed through rich and extensive interaction, finding this balance is a complex process associated with several tradeoffs for cooperators, such as those between being available for interaction and being interrupted, being unavailable and missing out on interaction, approaching the most knowledgeable individual for interaction or maintaining the network of actors etc. Failing to strike this balance will have negative effects for individuals and the cooperative work formations to which they belong.

The intention is therefore to explore how multitasking individuals manage to find a balance between task execution and articulation work in computer-supported cooperation, which challenges they face in the process, and how technology should be designed to support them. Achieving this purpose is of great importance for researchers with an interest in computer-supported cooperative work, designers of supportive IT, but also for cooperators active in modern organizations. Due to the challenge of the modern work context for individuals and how important it is for their productivity and well being that they strike a balance in work, the overall research question explored in this thesis is:

- How do individuals involved in computer-supported cooperative work strike a balance between taking active part in articulation work and task execution?

In order to find an answer to this overall research question it is useful to break it down into a number of specific questions. These questions are addressed more specifically in the included papers and contribute to a further developed understanding of the studied phenomenon.

As previously mentioned, cooperative work in modern organizations is heavily characterized by interdependencies and it is these dependencies that create a substantial need for interaction, especially

informal interaction, among cooperators. Because involvement in any one cooperative formation includes phases of individual work (during which the individual is most likely less open for establishing interaction with others) and the fact that cooperators are often multitasking, there are moments during which interaction is appropriate and other moments when it isn't. This situation accentuates the notion of *availability management* referring to "the ways in which a person signals to other persons in the surroundings (including also online contacts) if he/she is open to communication or not" (Harr and Wiberg 2008, p. 3f). This is an important aspect for finding a balance in cooperative work, bringing us to the following research question:

- How do cooperating and multitasking individuals manage availability in a physical/virtual work environment?

Cooperators do not interrupt each other without reason, they do it because they have an interaction need, e.g. a question, an urgent message or a suggestion that they want to present to other cooperators. Attempts to establish interaction could however have disruptive effects. Given that individuals are dependent on being able to focus on task execution in combination with the need for articulating work a tradeoff emerges. This is another important aspect for finding a balance in cooperative work that is addressed in this thesis, which can be expressed as the following question:

- How do groups of cooperating and multitasking individuals regulate the disruptive effects of interruptions without threatening their mutual interaction needs?

Taking into consideration what we know so far about the importance of interaction for cooperators as well as the vast amounts of interaction associated with participation in cooperative work, it is important to understand interaction search behavior in social professional networks. Failing to support interaction search behavior in a proper way will likely increase the levels of unwanted interaction and disruptive interruptions for cooperators. As a consequence, finding an answer to the following research question is of vital importance:

- How do cooperating and multitasking individuals go about searching for each other for establishing interaction without causing substantial amounts of disruptions?

As emphasized in the introduction individuals are commonly active in several cooperative work formations at the same time. This is a demanding situation when it comes to finding time both to execute individual tasks and to take part in articulation work. This highlights the importance of the final question:

- How do cooperating and multitasking individuals manage information and interaction associated with work articulation of multiple cooperative activities?

Through finding answers to these specific questions the main research question is addressed.

Having outlined the research questions, attention now turns to one of the most difficult choices associated with writing a thesis, i.e. what **not** to write about. This is important for preventing erroneous expectations and for providing clarity concerning the research aim. There are numerous factors that have some degree of influence on how any instance of cooperative work unfolds in practice. Hardly anyone would argue that aspects such as power relations, gender issues, legislation issues, formal interaction, economics, organizational rules and ethnicity do not influence how a cooperative work arrangement is structured and unfolds. For a single researcher it is impossible to cover even a handful of these aspects of which none is included in this thesis. Rather, the thesis focuses on the process of striking a balance between articulation work and individual task execution in cooperative work formations that are facing complex tasks, which are heavily reliant on informal communication and IT, and where no clear hierarchy exists among collaborators. No more, no less.

Due to the modern organization of work, multitasking is a fact of life and focusing solely on individual task execution is not an option. Different challenges with which this situation is associated have been extensively studied in previous CSCW research. However, as recent reports on various forms of overload indicate, cooperators are still struggling to strike a balance in their work. With a basis in previous research related to the challenges of computer-supported collaborative

multitasking, the intention is to explore how multitasking individuals manage to find a balance between individual task execution and articulation work in computer-supported cooperation, what challenges they face in the process, and how they can be supported. This understanding is essential for improving the foundation on which future research and designs of supportive IT are to be based, as well as for supporting cooperators struggling with finding a balance in work.

1.2 Entering the field of computer-supported cooperative work

In the process of writing this thesis four different practices of cooperative work in very different settings have been followed: a group of hunters, a group of researchers at a university, dispatchers and drivers in a logistic company, and collaborating teachers at a senior high school. Included in the thesis is also one paper (paper 4) that does not rest on empirical grounds but is based on an extensive overview of existing research. This paper will be further described in later chapters.

The empirical exploration was started by following a group of hunters carrying out several sessions of bird hunting (reported in paper 1). In this case, the researcher came as close as possible to the studied activity by actually participating as one of four hunters. Being involved in the activity enabled direct experience of the complexity of articulating the work of distributed and mobile hunters. At the same time as coordinating their collective activity the hunters were striving for successful outcomes in finding and shooting birds (i.e. the individual activity). Following this initial study a group of researchers active at the Centre for Distance-spanning Technology (CDT) at Luleå Technological University were studied. For a period of six months participant observation of an ongoing online media space session (called the e-corridor) was conducted, and the activities of its participants and their technology use were observed (reported in paper 2 and 3). During that period valuable insights into the interplay between virtual and physical cooperation were gained, for example the value of keeping an asynchronous communication channel (i.e. a public chat) open for supporting informal communication and development of awareness among cooperators. The next step was to conduct a study of coordination of vehicles at a logistic company (reported in paper 5). In this

study insights into the processes of interaction search behavior in a highly distributed social network of professionals were gained. A range of factors was found to be poorly supported in the used IT support and influenced the process of interaction search behavior of dispatchers (the role responsible for delegating tasks to drivers). For example, no support existed for recalling previous interactions, which was one of the factors found to influence the interaction search behavior of dispatchers. The fifth and final study (reported in paper 6) focused on individual management of participation in several virtual and physical instances of cooperation. The study was conducted in an educational context, i.e. a senior high school, and the results provided valuable input for understanding the everyday management of participation in numerous instances of computer-supported cooperation. Problems associated with usage of several non-interoperable CSCW systems for collaborative multitasking were highlighted.

As this thesis will show, striking a balance between task execution and articulation work in computer-supported cooperation is a complex process in which:

- Multitasking cooperators are constantly struggling to find a balance between focusing on articulation of work and individual task execution, commonly in relation to several cooperative work activities.

- Strategies for finding this balance are developed in relation to the context in which the activity takes place. Cooperative work formations over time 'design' their use of technology, structures, procedures and norms etc.

- Multitasking cooperators active in a physical/virtual work environment manage availability by relying on explicitly/implicitly and synchronously/asynchronously shared information. For interpreting information related to the availability of other cooperators, norms and understanding of non-norm behavior is of key importance.

- Cooperators regulate the disruptive levels of interruptions by taking the work context of themselves as well as the individuals they want to establish interaction with into consideration. If sev-

eral communication channels are available, the work context of others influences the selection of channel through which interaction is established.

- Interaction search is a process characterized by negotiations and is influenced by the availability of cooperators, results of previous encounters, estimated competence of cooperators, cooperators' willingness to assist as well as network maintenance efforts.

- Norms are important because of how they reduce the interaction needed for work articulation. In the absence of established norms, cooperators manage extensive amounts of interaction and information through applying various filtering strategies.

1.3 Thesis outline

The present volume consists of a collection of six papers and a cover paper. The main purpose of the cover paper is to blend the research documented in the individual papers, but also to complement papers on relevant issues that for some reason were not addressed in them. The cover paper consists of seven chapters of which you are currently reading the first (**Chapter 1**).

Chapter 2. This chapter presents an overview of previous research related to the overall purpose of this thesis. The chapter begins with a brief introduction to the field of CSCW, a field established in the 1980s that has received substantial attention from researchers from very different disciplines. The chapter continues by outlining several concepts that have been extensively elaborated on within the field, all related to the area of focus of this thesis. The chapter is finalized by an outline of various examples of more or less successful technologies developed in relation to these key concepts with the purpose of supporting computer-supported cooperative work.

Chapter 3. In this chapter some of the most influential theoretical frameworks for the research field of CSCW are outlined, i.e. distributed cognition, coordination theory and activity theory. The chapter is finalized by a description of how theory has influenced the work of this thesis.

Chapter 4. In this chapter the approach to the overall purpose of this thesis is described. This is done by first describing the overall re-

search objective and its inspirational roots, followed by a presentation and argumentation for the applied research approach, i.e. interpretative case studies explored through ethnographic techniques, and a description of the actual research process. This chapter is finalized by brief descriptions of the cases that provided the empirical basis for the present volume.

Chapter 5. In this chapter the individual papers and the results they provided for the exploration of the overall purpose of the thesis are presented. Every paper description is finalized by a short summary of its main results in order to provide clarity when moving on to later chapters.

Chapter 6. In this chapter the overall conclusions of the thesis are presented, structured according to the specific research questions. Based on these conclusions some practical implications for practitioners and for designers of supportive technology are also presented.

Chapter 7. In this chapter, conclusions in terms of the overall purpose of this thesis and of related research within the field of CSCW are drawn. Suggestions are also made about the directions in which future research should be moving.

The collection of papers is placed directly after the cover paper, and these are presented in the order in which they were written (not in the order they were published). The papers are reprinted without any major changes, although typographical, linguistic and other minor technical errors have been corrected. Incomplete or erroneous citations and references have also been corrected, and the included papers have been reformatted to a common standard as far as possible. These are the papers included in this thesis:

(1) Harr, R. (2002). Exploring the Concept of Group Interaction Through Action in a Mobile Context. In *Proceedings of the 13th International Conference on Database and Expert Systems Applications* (Aix-en-Provence, France, Sept. 02-06, 2002). London, UK: Springer-Verlag, pp. 567–576.

(2) Harr, R., and Wiberg, M. (2008). Lost in Translation: Investigating the Ambiguity of Availability Cues in an Online Media Space. *Behaviour & Information Technology*, vol. 27 (3), pp. 243–262.

(3) Scholl, J., McCarthy, J., and Harr, R. (2006). A Comparison of Chat and Audio in Media Rich Environments. In *Proceedings of the 2006 20th Anniversary Conference on Computer-supported Cooperative Work* (Banff, Alberta, Canada, Nov. 04-08, 2006). New York: ACM Press, pp. 323-332.

(4) Harr, R., and Kaptelinin, V. (2007). Unpacking the Social Dimension of External Interruptions. In *Proceedings of the 2007 International ACM Conference on Supporting Group Work* (Sanibel Island, FL, Nov. 04-07, 2007). New York: ACM Press, pp. 399-408.

(5) Harr, R., Wiberg, M., and Whittaker, S. (Submitted to journal). The Survival of the Social: Social Interaction Foraging in Highly Distributed Professional Social Networks.

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Chapter 2

CSCW, Theoretical Concepts and Technological Support

In this chapter I begin by providing a short description of the research field of CSCW, followed by a description of previous research and a number of theoretical concepts related to computer-supported cooperative work. The chapter is finalized by an overview of existing technology for supporting cooperative work in modern organizations with a specific focus on technology supporting the previously outlined concepts.

2.1 Computer-Supported Cooperative Work

One of the factors behind the emergence of the research field of CSCW is the change in the organizational environment described in the introduction (Bannon 1993). Other contributing factors (see Bannon 1993) are peoples' expectations about systems to support their joint

endeavors and researchers' disappointment with the HCI field and how it neglected social aspects of work. In 1984, Irene Greif and Paul Cashman organized an interdisciplinary workshop on how to support people in their work arrangements with computers, during which the term Computer-supported Cooperative Work was first used (Greif 1988). Today the research field of CSCW is well established with a wealth of conferences, journals and papers addressing the very same topic. The scope of the field is however somewhat unclear, perhaps due to its attraction to a very heterogeneous set of researchers (Schmidt and Bannon 1992) and several attempts have been made to articulate definitions of the field (e.g. Greif 1988, Bannon and Schmidt 1989, Suchman 1989), but no general definition has been agreed on. This thesis adopts the definition by Schmidt and Bannon (1992 p. 5) that: "CSCW should be considered as an endeavor to understand the nature and requirements of cooperative work with the objective of designing computer-based technologies for cooperative work arrangements". Relying on this definition of the term implies that CSCW is a design oriented research field (the CS indicates that this is a correct assumption) where researchers' efforts should lead to improvements in supportive technology and that this design should be based on a thorough understanding of "the nature and requirements of cooperative work" (Schmidt and Bannon 1992, p. 5). As the ambition expressed in the definition is the support of authentic arrangements for cooperative work, field studies of these arrangements as they unfold in various domains are indeed valuable.

The last two letters in the abbreviation CSCW (CW) are referred to as standing for Collaborative Work, Collective Work, or Cooperative Work. See Schmidt and Bannon (1992, Schmidt 2006) for a thorough discussion of this. In this thesis, the term Cooperative Work is adopted, and used to describe something that takes place when mutual dependence exists between individuals and they need to cooperate in order to reach the goal of the joint activity (Schmidt 1991). This degree of dependence does not delimit itself to situations where individuals are dependent upon one another in such a way that they could have managed as good on their own (but for some reason choose to work together). Rather it means that they are dependent upon each other's outcomes for doing their own work. This dependency causes a need for

secondary activities (overhead activities) for mediating and securing cooperative relationships, such as who should be doing what, where and when. But also, as tasks have been assigned, individuals are expected to accomplishing these in accordance with certain criteria of how, at what level of quality and so on. In addition, work performed by individuals has to be articulated so that it all contributes in a satisfying way to the completion of the overall activity (Schmidt and Bannon 1992).

As previously emphasized, articulation of cooperative work in modern organizations is to a large extent managed through various forms of rich, extensive and often informal communication (Galbraith 1977, Katz and Tushman 1978, Schmidt and Bannon 1992, Mintzberg 1999). The concept of *informal communication* has received considerable attention in previous CSCW research (e.g. Kraut et al. 1990a, 1990b, Whittaker et al 1994, Nardi et al. 2000, Jeffrey and McGrath 2000, Luo and Olson 2006) and one of its payoffs is the promotion of an increased awareness among cooperators (Nardi et al. 2000, Kiesler and Cummings 2002). Ever since early CSCW studies (Hughes et al. 1988, Heath and Luff 1991 and 1992, Harper and Hughes 1993) showed how cooperators managed to coordinate their efforts in a smooth and efficient manner without causing disruptions, the concept of *awareness* have a played a key role in the field (e.g. Dourish and Belotti 1992, Dourish and Bly 1992, Nardi et al. 2000, Borghoff and Schlichter 2000, Kiesler and Cummings 2002). Attempts to promote development of awareness among cooperators across distances have however turned out to be somewhat problematic. A bitter side effect of these efforts, in combination with modern work arrangements, tends to be a radical increase in work fragmentation and *interruptions*. This is another concept that has received significant attention (e.g. Rouncefield et al. 1994, Hudson et al. 2002, Speier et al. 2003, Czerwinski et al. 2004, Iqbal and Horvitz, 2007). Interruptions commonly occur as attempts to establish interaction are made in situations where the interrupted individual is busy doing something else. The disruptive effects of interruptions can be substantial and as a consequence it becomes important that individuals can mediate and understand the appropriateness of establishing interaction with each other. This is a need that accentuates what CSCW researchers term *availability man-*

agement (e.g. Ljungberg 1999, Wiberg 2002, Hudson et al. 2003, Begole et al. 2004). As work in modern organizations typically involves taking part in several cooperative work formations at the same time, individuals are often working on multiple tasks simultaneously, i.e. they are *multitasking*. This is a term that has also received some attention in CSCW research (e.g. O'Connail and Frohlich 1995, Czerwinski et al 2004, Mark et al. 2005, Wiberg and Whittaker 2005, Su and Mark 2008) and is often used to describe concurrent work or work being performed in immediate series. As a consequence of multitasking, individuals frequently make switches between working on different tasks. This phenomenon is within CSCW termed *task switching* (e.g. Bannon et al. 1983, Card and Henderson 1987). Even if individuals have always switched tasks while working, the increased frequency with which these switches occur in modern organizations has accentuated the importance of the concept.

With the field of CSCW and some of its key concepts related to managing work in modern organizations now introduced, it is time for a more extended presentation of these concepts that will be further elaborated throughout the thesis.

2.2 Theoretical Concepts

A number of key theoretical concepts are put forward in this section for describing, understanding and theorizing about computer-supported cooperative work. These are: informal communication, awareness, interruptions, availability management, and multitasking/task switching.

2.2.1 Informal Communication

Informal communication is one of the most dominant activities in how work is actually done in many settings. As Kraut et al. (1990a) remark:

> People read at their desks but are interrupted by phone calls. They leave to attend a department meeting but stop on the way to discuss a matter with a colleague. To answer questions about office procedures, they call to the person at the next desk rather than consult the appropriate manual. The conversations seem fluid and undersigned and yet, clearly, work is being accomplished. (Kraut et al. 1990a, p. 3)

Kraut and colleagues (1990a) distinguish between four different types of communication in organizations: *scheduled* (planned and arranged by the involved individuals), *intended* (an individual targets another individual for communication on a specific topic), *opportunistic* (an individual encounters another individual by chance and is reminded of wanting to interact about a certain topic), and *spontaneous* (interaction that is not planned and is triggered by individuals accidentally meeting each other and initiating interaction). In order to provide a glimpse of the proportions between these communication types, Kraut et al. (1990a) conducted a short study in a research and development organization. They found that of 117 conversations, merely 12% were scheduled, 36% were intended, 21% were opportunistic, and 31% were spontaneous. Even if overlaps between these categories are likely to exist (e.g. if opportunistic communication is initiated when people are co-located for a meeting), this study accentuates something that many other scholars (e.g. Schmidt and Bannon 1992, Fish et al. 1993, Whittaker et al 1994, Nardi et al. 2000, Jeffrey and McGrath 2000, Luo and Olson 2006) have emphasized: informal communication is very important for computer-supported cooperation, especially when taking on tasks characterized by uncertainty (Kraut et al. 1990a) and equivocality (Daft and Lengel 1986).

Schmidt and Bannon (1992) acknowledge the role of informal interactions in serving important psychological functions for cooperating individuals, such as development of emotional support and companionship, but also strongly emphasize the importance of informal interactions for conducting actual work. In fact, it has been shown that when office workers only work according to office procedures and do not interact informally, work tends to halt within a short time (Schmidt and Bannon 1992). Informal communication differs from other communication forms in being more frequent, interactive, and expressive (Daft and Lengel 1986, Kraut et al. 1990a), and some of the benefits of supporting informal communication in cooperation are in how it enables people to tune into the progress of one another's work, monitor the overall group process, coordinate actions, solve problems together, foresee each other's weaknesses and strengths, help each other out (Nardi et al. 2000, Kiesler and Cummings 2002), and sup-

port development of common ground[3] (Luo and Olson 2006). These are important mechanisms in computer-supported cooperative work on highly ambiguous and uncertain tasks (Fish et al. 1993). As reported by several scholars (e.g. Kraut et al. 1990a, 1990b, Whittaker et al. 1994, Jeffrey and McGrath 2000, Kiesler and Cummings 2002) informal communication is generally mediated by physical proximity, for example as co-located colleagues bump into each other at high traffic areas such as a photocopier or coffee machine (Isaacs et al. 1996). According to Kiesler and Cummings (2002) a distance of 30 meters is enough to produce a reduction in daily contact and the occurrence of informal communication. Due to the characteristics of modern organizations, measures need to be taken if the efficiency of cooperation is to be maintained.

Based on the notion that communication is the exchange of information between people (e.g. Dix and Beale 1996), there are also instances of communication that are not informal (at least not as the term is used by most scholars) nor formal. Scholars have put forward the concepts of, for example, feedthrough (information sharing through manipulation of shared objects or artifacts) (Ljungberg 1999), or stigmergy (information sharing through physical traces of work of efforts previously made by oneself or by others) (Christensen 2008 drawing on Grassé 1959). The importance of these instances of implicit[4] communication is to a large extent dealt with in research related to the next theoretical concept, awareness.

2.2.2 Awareness

As the field of CSCW was established it was found that cooperators managed to work individually and at the same time monitor the work of others and the context of their joint effort. This reduced the usefulness of categories such as 'conversations' and 'workflows' for grasping the ways in which coordination and integration of cooperative work

[3] The concept refers to *… a great mass of knowledge, beliefs, and suppositions they [participants] believe they share* (Clark 1996, p. 12, cited in Romero and Markopoulos 2005, p. 1007). The concept is very much related to the concept of norms in how it describes mechanisms for reducing interaction needed among cooperators.
[4] Implicit in the sense that communication is not intended but is rather a byproduct of other activities.

unfold (Schmidt 2002). Early CSCW studies (e.g. Hughes et al. 1988, Heath and Luff 1991 and 1992, Harper and Hughes 1993) documented how cooperators integrated their efforts in a smooth and apparently effortless way without causing too many disruptions. Based on these early studies, the term 'awareness' was coined and has ever since been a key concept in CSCW.

The notion of awareness, generally defined as "an understanding of the activities of others, which provides a context for your own activity" (Dourish and Belotti 1992), has been associated with a wide range of benefits in cooperation, such as: enabling individuals to tune in to the progress of others (Dourish and Belotti 1992, Borghoff and Schlichter 2000), monitoring the overall group process and coordinating actions (Nardi et al. 2000, Kiesler and Cummings 2002), stimulating informal communication (Borghoff and Schlichter 2000), supporting evaluation of the individual's actions in relation to the group process and goals, enabling a feeling for who is around, who is talking to whom and what activities are occurring (Dourish and Bly 1992). Even though the concept has received considerable attention in CSCW the use of the term is far from coherent, which has led to a number of categorizing efforts (Greenberg et al. 1996, Liechti, 2000). Liecthi (2000) reviews four categories of awareness: group awareness, workspace awareness, contextual, and peripheral awareness while Greenberg et al. (1996), with some overlap, divide group awareness into the categories of: informal awareness, group-structural awareness, social awareness and workspace awareness. This could seem confusing, and the role of the concept is under increasing strain as it is used in increasingly diverse ways (Robertson 2002). CSCW researchers are far from confident when using the term and often use it in combination with various adjectives (Schmidt, 2002). The understanding of what others are doing is important in any social context for supporting informal interaction and the development of a shared culture. However, for interdependent individuals taking on complex tasks, more specified and work related concerns are central (Schmidt 2002). This claim becomes even more important when individuals are involved in several cooperative work arrangements running in parallel, as broadcasting too much information will have disruptive effects (Dabbish and

Kraut 2004). Schmidt describes the role of awareness in computer-supported cooperative work situations as follows:

> It is clear that the phenomena of which actors are supposedly aware when the term 'awareness' is used in this line of research, are not merely tangential or external to the ongoing activities that constitute a cooperative effort. The term 'awareness' here denotes taking heed of unfolding events and of possibly unfolding events; of things being done, of things done, and of things in need of being done; of developments within the joint effort that may be advantageous, detrimental, hazardous, etc. for one's own work; of occurrences that makes one's own work more urgent or less so, that require action or inaction, that necessitate changes to the intended course of action, etc. – all of it directly motivated by the actors' being interdependent in their work and hence by the unavoidable requirements of coordinating and integrating their various actions. (Schmidt 2002. p. 290)

Following this description it is easy to understand the voices arguing for providing distributed actors with the same awareness that is often seen in co-located work settings. For the cooperating and multitasking individuals it is of pivotal importance that acquiring awareness does not increase the workload associated with cooperative work. Several researchers (e.g. Dourish and Bly 1992, Heath and Luff 1992, Dourish 1997) argue for awareness to be gathered without demanding additional efforts from individuals, in the words of Dourish and Bly (1992) it is "[...] gathered passively, while other workplace activities progress" (Dourish and Bly 1992, p. 541). With that said, the next question, which is referred to by Schmidt (2002) as the problem with awareness, is how individuals without too much effort acquire information of what is going on around them and make sense out of it. This is of key importance for understanding work of cooperating and multitasking individuals and for designing supportive technology. On one hand awareness is considered to be generated as an unintended byproduct of individuals' actions, on the other some consider it to be based on intentionally shared information (e.g. Heath and Luff 1992, Benford and Fahlén 1993, Rodden 1996). Heath and Luff (1992) provides the following example of conscious awareness sharing from their study of line control rooms in the London underground:

> [...] whilst speaking to a signalman on the telephone to ask whether he has corrected the running order of a couple of 'out of turn' trains, the Controller [a person who coordinates the day to day running of the railway] not only coordinates his talk with his co-conversationalist, but simultaneously emphasizes, by volume and repetition of certain elements to the DIA [the Divisional

> Information Assistant, a role that provides information to passengers and communicates with station managers]. (Heath and Luff 1992, p. 16)

Heath and Luff further emphasize the smoothness of individuals when choosing an interactional modality for sharing and gathering aspects of their own or others' work. Partly based on this description of how awareness is developed among cooperators, Schmidt (2002) concludes that awareness is not the outcome of passive gathering of information, but is rather actively searched for and gathered by skilled practitioners.

2.2.3 Interruptions

Most of us are familiar with the frustration associated with trying to focus on an important task and being constantly distracted by incoming calls, visits, and computer mediated updates (e.g. notification of an incoming email). Every one of these distractions that demands our attention, while we are doing something else, is an interruption. In what follows the term is defined as "some abrupt occurrence that pauses or halts an ongoing activity".

The modern workplace is characterized by fragmentation and a high frequency of interruptions (e.g. Rouncefield et al. 1994, O'Connail and Frohlich 1995, Czerwinski et al. 2004, Iqbal and Horvitz, 2007). One of the factors behind this situation is the increased need for informal communication to achieve efficiency and productivity (Baecker et al. 1995, Dabbish and Kraut 2004, Gonzalez and Mark 2004, Czerwinski et al. 2004) as well as an increased reliance on ICT for communication (Markels 1997, Dabbish and Kraut 2004, Horvitz et al. 2005). These technologies (e.g. e-mail, instant messaging, cell phones, audio/video conferencing tools) have made communication more convenient but have also caused an increase in interruptions (Dabbish and Kraut 2004). Some instances of ICT even prompt task interruptions themselves, for instance e-mail clients providing interruptions when notifying about incoming messages (Markels 1997).

Some scholars (e.g. Sproull 1984, Panko 1992, Whittaker and Frohlich 1994, Hudson et al. 2002, González and Mark 2004) report on the fragmented nature of organizational contexts by focusing on the work of managers or other professional work roles. These reports show that

workers spend a considerable amount of time in short conversations (Panko 1992, Whittaker and Frohlich 1994, Hudson et al. 2002), of which up to 90 percent are not planned (Whittaker and Frohlich 1994). This suggests that these conversations may often constitute interruptions for at least one of the involved parties (Rouncefield et al 1994). Gonzalez and Mark (2004) found that their subjects (analysts, managers and software developers) on average were able to focus on a task for about three minutes before switching to another task, while O'Connail and Frohlich (1995) report on a study of mobile professionals in which the respondents in general were interrupted more than four times every hour, and that in 40 % of the cases the disrupted task was not resumed immediately after the interruption.

Due to its impact on organizational work the concept of interruption has received considerable attention in CSCW and HCI research. Previous research on interruptions has mainly adopted one of the following three foci: effects of interruptions on the individual, ways to stop disruptive interruptions from occurring, and ways to limit the damage caused by interruptions (for a more thorough review see Harr and Kaptelinin 2007).

Most studies exploring the effects of interruptions consider them to affect our everyday work in a negative way (Mandler 1984, Weick 1995, Burmistrov and Leonova 1997, Perlow 1999) mostly due to how they affect our mental state (Zijlstra et al. 1999, Bailey et al 2001). Other studies describe a more complex picture and suggest that the effects of interruptions are not necessarily negative (O'Connail and Frohlich 1995, Zijlstra et al. 1999) and others even report on positive effects on work (O'Connail and Frohlich 1995, Speier et al. 1997, 1999, Bailey et al. 2000, 2001). Burmistrov and Leonova (2003) suggest that interruptions facilitate individual performance in the case of simple tasks, but inhibit performance in the case of complex tasks. Cutrell and colleagues (2001) found that the disruptive effect of an interruption was dependent on timing but also the relevance of an interruption for the current task. Not surprisingly, interruptions that were irrelevant to the current task caused more disruption than those that were relevant to the task at hand. Similar results concerning the consequences of interruptions were found in other studies (Burmistrov and Leonova 1996, Speier et al 1997, Bailey et al 2000, Czerwinski et al

2000, Adamczyk and Bailey 2004). This somewhat ambivalent characteristic of interruptions has created a view of them characterized by a tension between avoidance and appreciation (Hudson et al. 2002).

Other researchers have focused on how to stop disruptive interruptions from occurring (e.g. Kristoffersen and Ljungberg 1999, Begole et al. 2004). The most obvious way to do this is to make others aware that we do not want to be disturbed (an aspect of cooperative work that gave rise to the concept of availability management, further explored in section 2.2.4). There are numerous examples of systems providing individuals with information related to whether or not their colleagues are in such a situation that it is or is not appropriate to establish interaction with them. These systems either rely on explicit or implicit sharing of availability information and are outlined in detail in the following section.

A third focus in previous interruption research is on reducing their negative effects. Some studies investigating the disruptive effects of interruptions (e.g. Czerwinski et al. 2000, Adamczyk and Bailey 2004) also suggest certain strategies for making interruptions less harmful by improving the timing of interruptions or only allowing interruptions relevant to the task at hand. Other strategies for minimizing the damage caused by interruptions include using different communication channels or modal outputs (e.g. Arroyo et al. 2002).

When considering what we know so far about interruptions and interruption handling, cooperators face several fundamental dilemmas. First, if a cooperator decides to make himself unavailable for interaction in order to avoid interruptions, he may also miss wanted interaction. Second, sharing information about availability with others could itself become a burdensome task (for the individual cooperator as well as for others). Third, if a cooperator decides to postpone dealing with an interruption this might enable paying more attention to a current task, but will at the same time increase the number of interruptions and create one more thing to take care of in the future. Managing these dilemmas is not a trivial task and there are no universal solutions. In each particular case cooperators need to find their optimal tradeoffs in order to secure that a balance between articulation of work and individual task execution is struck. There is not much insight in existing research on how to use specific strategies in real-work con-

texts as most prior studies of interruptions are based on laboratory experiments (e.g. Cutrell et al. 2000, Bailey et al. 2001, Burmistrov and Leonova 2003, Altman and Trafton 2004), with a specific focus on individual attitudes and behavior towards interruptions (e.g. Horwitz and Apaible 2003, Czerwinski et al. 2004, Dabbish and Kraut 2004). They do not thoroughly take into account the social context in which interruptions take place.

2.2.4 Availability management

If an individual decides to approach another individual to establish interaction and a conversation actually takes place, the initiator of the conversation is likely to satisfy their communication need and can proceed with their work. For the recipient, the situation is different as he or she not only has to focus on the communication need of the initiator, but has also to remember the content and status of their original activity (Wiberg and Whittaker 2005). Due to the multitasking nature of modern work and the increase in communication channels and mobile technology, these situations are likely to occur with a higher frequency than before. As a consequence availability management becomes a focal concern. Here, availability management is defined as "the ways in which a person signals to other persons in the surroundings (including also online contacts) if he/she is open to communication or not" (Harr and Wiberg 2008, p. 3f).

There are several different approaches to regulating the load of communication and information that reaches the individual, including those relying on explicit approaches, i.e. those demanding direct effort from the individual concerned (e.g. Ljungberg 1999, Wiberg 2002, Begole et al. 2004). Such explicit availability management has been defined as "the ways in which a person consciously signals to other persons in the surroundings (including also online contacts) if he/she is open to communication or not" (Harr and Wiberg 2008, p. 4). When we write 'telephone meeting 11.00-12.30' on our small whiteboard outside our office, this is an explicit act that is most likely performed with the purpose of preventing disruptions. Implicit approaches to managing availability, in contrast, generally rely on the sharing of awareness information between individuals (e.g. Hudson et al. 2003,

Begole et al. 2004, Fogarty et al. 2004a, 2004b, 2005). Implicit management of availability has been defined as "the ways in which a person unconsciously signals to other persons in the surroundings (including also online contacts) if he/she is open to communication or not" (Harr and Wiberg 2008, p. 5).

In a co-located work environment availability is commonly managed with little effort, by relying on subtle but well practiced mechanisms for determining or signaling readiness for interaction, and to manage transitions from being engaged to not being engaged and vice versa (Knapp 1978, Argyle 1988). Individuals are, for example, good at signaling unwillingness to interact through gaze aversion, which in a co-located setting often results in no interaction taking place. In addition, someone who is considering initiating a conversation can assess another person's willingness to interact without that person knowing that the assessment has taken place (Fish et al. 1993). When reviewing previous research it is apparent that the ways in which availability has been managed in computer mediated communication applications differ from how availability is managed in the physical workplace. In collocation both explicit- (e.g. Hudson et al. 2002) and implicit strategies have been documented (e.g. Knapp 1978, Argyle 1988), but in computer mediated work settings the explicit approach has almost exclusively been applied (Ljungberg 1999, Milewski et al. 2000, Wiberg 2002).

2.2.5 Multitasking and Task Switching

Recent empirical work has addressed the fragmented nature of work for individuals in today's organizations (e.g. O'Connail and Frohlich 1995, Leroy and Sproull 2004, Mark et al. 2005, Wiberg and Whittaker 2005, Su and Mark 2008). This fragmentation complicates the work situation for the individual and forces him or her to make frequent switches between tasks.

Mark and colleagues (2005) established that information workers typically manage 12 different projects simultaneously, and Baron (2008) revealed that in a study of multitasking activities of undergraduates, 98 % of the 158 subjects were involved in at least one computer-based or offline activity while at the same time using IM to an-

swer a questionnaire. While conducting a study reported in this thesis (papers 2 and 3) one of the respondents said, with a proud expression on his face, that he had a record of participation in seven parallel video conferencing sessions. There is no doubt that multitasking is a characteristic of work in the modern organization but there are different opinions concerning what the term really means (Dzubak 2008). Most would probably say 'doing several things at the same time', but as Dzubak (2008) points out this is actually very difficult when it comes to work on complex tasks. Baron (2008) provides a similar discussion as she defines multitasking as "making simultaneous demands upon our cognitive or physical faculties" (Baron, 2008, p. 37), but also emphasizes that the term is often applied on situations where several tasks are performed in immediate series. Su and Mark (2008) emphasize multitasking as a permutation of switching between various individual tasks and switching between individual work and interaction with others. As a consequence instances of cooperation are also instances of multitasking in the sense that work is characterized by a mixed focus between the individual and the collective aspects of work.

Task switching is the process of switching from working on one task to working on another and it is quite common that these switches are provoked by interruptions (Card and Henderson 1987). Task switching is not a new phenomenon; what has changed however is the pace and frequency with which these switches occur. Bannon and colleagues (1983) identify several reasons why we decide to switch tasks: (1) we decide to start working on a task that we are reminded of while doing another task, (2) we have several tasks that are expected to be done at the same time, (3) we are working on tasks that involve long periods of waiting, (4) we are working on subtasks within a larger task, and (5) we are forced to switch tasks due to holdups such as computer breakdowns. Card and Henderson (1987) added three other reasons for switching tasks, namely (6) external interruptions, (7) making a switch to another current project (e.g. when time is scheduled for work on other tasks), and (8) shifting to a different working environment (e.g. an environment for creating figures). In the modern organization the costs of constantly switching between tasks have been identified as considerable. What is worth mentioning in situations of collaborative multitasking is that when a user is actively engaged in working on a

task in one project, work in other projects is likely to proceed. This creates a situation where the individual worker needs to be aware of the whereabouts of others in various shared projects even if he or she is not actively working on tasks directly related to more than one of them.

2.3 Discussion of related research

The field of CSCW is relatively new and after 25 years we are still searching for concepts, theories and methodologies for understanding cooperative work and ways for supporting it with IT. The concepts presented in the sections above are all important for cooperative work, but there are some shortcomings in the ways we have addressed them so far. The concept of awareness that was coined at an early state has been widely explored in work settings as well as laboratory settings and few question its importance for cooperative work. There are however concerns related to the concept (see Schmidt 2002), arguing for more thorough explorations of what it is that cooperating individuals actually need to be aware about. At the same time there are several other concepts that have proved themselves essential for understanding cooperative work, especially when computer-supported cooperative work involves multitasking and distributed cooperators in modern organizations. These concepts (i.e. interruptions, availability management, and multitasking/task switching) have received a varying degree of attention in CSCW research, but have in general suffered from different shortcomings when it comes to the scope of research, methodology, and research procedures.

Interruption is a concept that has received substantial attention, unfortunately most studies of interruptions and interruption management are laboratory experiments conducted in controlled environments. As a consequence, these studies provide limited insights into the effects and management of interruptions in real work environment and fail to take into account the social context where cooperating individuals are active.

When it comes to availability management, research targeting this concept focuses on either computer mediated or physical work settings and few studies focus on the interplay between these two. This is a hazardous strategy due to how integrated these contexts are in real

world cooperation (see paper 6). What is even more striking is how little previous research has focused on implicit availability management in computer mediated work environments. This is an aspect of availability management that is specifically addressed in one of the included papers (paper 2), while being touched on in several of the others.

When it comes to multitasking and task switching, significant effort has been directed to describing the fragmented workplace and the frequent switches of task that are made by the individual. Since the 1980s, researchers (e.g. Card and Henderson 1987) have however focused on how to remedy the potentially negative effects of multitasking with a main focus on individuals and their tasks. Few efforts have been made to explore multitasking between various cooperative activities. Reports of negative experiences of cooperators due to the multitasking nature of modern work are as common today as ever before, indicating a need for further research.

We have come far as CSCW researchers in our understanding of computer-supported cooperative work and the challenges that are associated with it. However, based on the identified shortcomings in previous research, a need for complementary research is apparent. This research should focus on real life contexts and avoid isolation of single concepts. This is important for understanding the processes through which individuals strike a balance in cooperative work.

2.4 Technological support for managing cooperative work

Organizations are increasingly reliant on IT for managing work (Olson and Olson 2001, Kraut et al. 2006). IT has come to form the glue that binds cooperators together, but is also one of the factors that have made the modern workplace so challenging. The rest of this chapter is devoted to presenting various forms of IT support related to the theoretical concepts presented above.

2.4.1 IT-support for informal communication in distributed groups

Several researchers (e.g. Monge et al. 1985, Fish et al. 1990) identified on an early state how the likeliness of cooperation between two individuals decreased when distance of separation increased and that one of the reasons for this was difficulties associated with reaching the levels of informal interaction needed to create and maintain work relationships (Hollan and Stornetta 1992). The lack of supportive technology for remedying this shortcoming was soon recognized (e.g. Kraut et al. 1990a, Whittaker and Frohlich 1994) and vast numbers of research projects in the early 1990s focused on extending the benefits of spontaneous and informal communication to distributed work (e.g. Borning and Travers 1991, Cool et al. 1992, Fish et al. 1993, Bly et al. 1993, Tang and Rua 1994, Lee et al 1997).

These attempts can be divided into two different types of prototype systems, of which the first type provided an open audio/video link between public areas of two sites with the intention to promote informal conversations (Fish et al. 1990, Bly et al. 1993). The success of these attempts was however rather limited, and even if some degree of informal communication occurred it was never at the same level as in real world settings (e.g. Kraut et al. 1990a). What the systems did manage to do was to mediate some feeling of shared context and culture across sites. (Fish et al. 1993). The other type of system involved point-to-point or multiple-points desktop video (e.g. Borning and Travers 1991, Mantei et al. 1991, Dourish and Bly 1992, Fish et al 1993, Tang and Rua 1994, Tang et al. 1994, Obata and Sasaki 1998). One of these systems, The Cruiser system (Fish et al 1993), promoted an availability check, or 'glance', through which one worker could get a short glimpse of the work situation of another worker in order to evaluate if interaction was appropriate (similar functions were also found in several other of these systems). Even if the system failed to replicate face-to-face interaction, and even if it was experienced more as a phone than as face-to-face interaction, people always chose videophone over phone alone. When establishing virtual offices users experienced ease in maintaining background awareness of one another's progress, which reduced the cost of initiating interaction. A less successful function was one that was trying to replicate 'bumping into'

one another in the corridor by randomly connecting two users. Ninety-seven percent of these connections were closed down immediately (Fish et al. 1993). In another system, the Montage system (Tang and Rua 1994), attempts were made to decrease the intrusiveness of initiating interaction by introducing fade-in video. This was however experienced by users as more disruptive than the occurrence in physical settings that it was intended to mimic, namely walking down the hallway and looking into offices that are passed by (Tang and Rua 1994, Tang et al. 1994). Cool et al. (1992) report on usage of the VideoWindow system and establish that the rate of spontaneous communication through the system did not reach half of that for comparable face-to-face opportunities. Obata and Sasaki (1998) presented similar results based on their evaluation of their prototype system and since then few scholars have relied on such approaches for supporting informal communication, instead more lightweight approaches have been put forward.

More recent work reports on instant messaging (Nardi et al. 2000, Herbsleb et al. 2002, Isaacs et al. 2002), email (Kraut and Attewell 1997) and chat (Herbsleb et al. 2002) as technologies for supporting informal communication across distance. Herbsleb et al. (2002) developed a prototype called RVM (Rear View Mirror) for providing presence awareness, instant messaging and group chat for its users. In RVM the instant messaging feature was used by opening up an IM window, writing a message, and almost immediately a pop-up window was shown on the screen of the recipient. In addition the RVM system also supported group chat where group members could write text messages to each other without these messages being visible for individuals outside the group. Even though the system use was initially high, it turned out that after some time 90 % of the possible users didn't use the system. Some of the reasons behind this decrease in usage were, according to Herbsleb and colleagues (2002), that IM and chat didn't fit well with established communication habits, failure to see informal communication as a work related activity and that people feared being overwhelmed by these new kinds of messages.

2.4.2 IT support for promoting awareness

Several of the systems that were described in the previous section for supporting informal communication across distance were also either designed for, or had as one of their side effects, that an increased awareness across sites was developed. Since an experiment connecting the offices in Palo Alto and Portland together through the Media Space system (Bly et al. 1993), large numbers of research projects have focused on providing awareness through the use of more or less sophisticated technological support. Given the nature of awareness i.e. how it supports articulation of work without demanding overhead activities by individuals, it is easy to understand these efforts. Many researchers (e.g. Dourish and Bly 1992, Gaver et al. 1992, Fish 1993, Handel and Herbsleb 2002, Isaacs et al. 2002) have for example been interested in how constant connectivity can be used to support workplace awareness (Want et al. 1992, Greenberg 1996), i.e. the ability to use technology to mediate what colleagues are doing so as to provide a better basis for cooperation. The combined efforts of these research projects and others have influenced development of a new genre of computer mediated computer systems, commonly called awareness systems defined as "systems whose purpose is to help connected individuals or groups to maintain a peripheral awareness of the activities and the situation of each other, e.g., their well-being, their availability for interaction, or an overview of their activities, etc" (Markopoulos et al. 2005, p. 2128). Numerous types of system fall under this definition, such as:

- Systems making use of desktop video cameras through which the whereabouts of individuals are shared through continuous video/audio channels (e.g. Abel 1990, Mantei et al. 1991, Bly et al. 1993, Tuddenham and Robinson 2009).

- Systems running on mobile devices enabling users to via audio or graphics get a feeling about activities of others and communicate through IM (Isaacs et al. 2002).

- Systems promoting sharing of short video glimpses between co-operators, which allow fellow workers to glance into offices of col-

leagues as when physically walking down a hallway (e.g. Tang et al. 1994).

- Systems providing still images of other people's offices in order to support awareness and availability management (e.g. Dourish and Bly 1992, Lee et al. 1997).

- The most widespread awareness systems, which have made the leap from being a prototype system to being used by millions, are various forms of IM systems. The way that these provide remote peers with awareness information is through support of informal conversations and automatically or explicitly manipulated status features. These systems have been the object of study in a wide range of research papers on awareness (e.g. Nardi et al. 2000, Herbsleb et al. 2002, Isaacs et al. 2002, Hancock et al. 2009)

Explorations of these systems and their ability to promote awareness were initiated in the 1990s and recent work shows that the same types of systems still play a central role. This includes work on, for example, the use of IM for promoting interpersonal awareness (Hancock et al. 2009), video framing for promoting empathy formation (Nguyen and Canny 2009), and media spaces for promoting social telepresence (Nakanishi et al. 2009). One can conclude, based on this overview, that cooperators have a genuine interest in knowing what others are doing and that a wide range of technologies have been considered for this purpose.

2.4.3 IT support for managing interruptions

As outlined in section 2.2.3, our review of previous interruption research (presented in detail in Harr and Kaptelinin 2007) shows that a great deal of previous interruptions research has focused on how we can prevent disruptive interruptions from occurring and how we can make them less harmful. One of the reasons for designing different kinds of 'office shares' is to enable sharing of availability information among cooperators (e.g. Dourish and Bly 1992, Fish et al 1993, Tang et al. 1994). This is an ambition that, if successful, can prevent disruptive interruptions from taking place. Other systems are designed specifi-

cally for reducing disruptive effects of interruptions as they happen (Lamming et al. 1994, Ljungberg 1999, Czerwinski and Horvitz 2002, Wiberg and Whittaker 2005). These systems acknowledge interruptions as a natural part of modern work and focus instead on how to reduce their disruptive effect. One such approach is based on enabling negotiation concerning when and how an interruption should take place (e.g. Ljungberg 1999, Wiberg and Whittaker 2005). The Negotiator system (Wiberg and Whittaker 2005) promotes negotiation between the interrupter and the interruptee about alternative times for a conversation to take place. The system (figure 1) recognizes the occurrence of interruptions as a natural part of modern work and does not prevent them from happening. As a matter of fact, this approach actually increases the amount of interruptions, but could reduce their disruptive effects. The system also supports negotiation about the time and who should be responsible for the next contact, and by doing so brings to synchronous communication some of the benefits commonly associated with asynchronous media for managing interruptions (O'Connail and Frohlich 1995, Rodenstein et al. 1999).

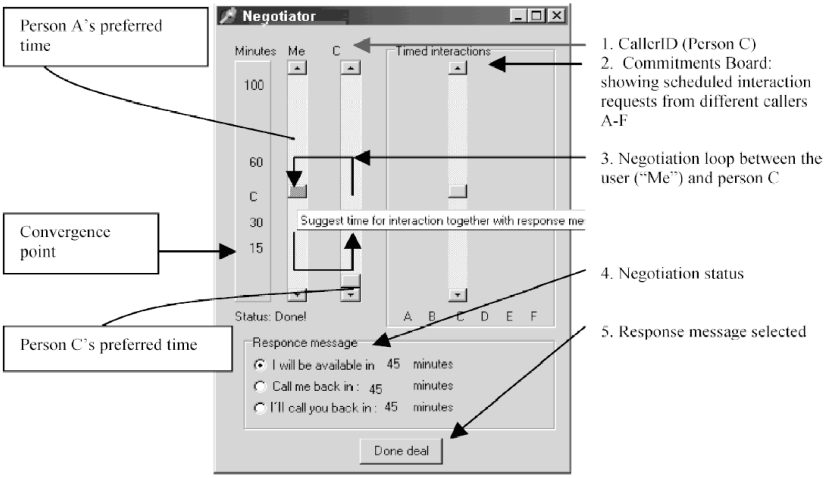

Fig. 1. The Negotiator system user interface (Wiberg and Whittaker 2005).

Another type of system is designed to reduce the disruptive effect of interruptions by shortening the resumption lag, that is, the time

needed to collect one's thoughts and resume work on a task once the interruption is over (e.g. Czerwinski et al. 2002, 2004, Kaptelinin 2003, Robertson et a. 2004, Altman and Trafton 2004). This type of system will be described in more detail in section 2.4.5.

2.4.4 IT support for managing availability

Another type of IT support that can reduce the disruptiveness of interruptions, for example supporting the timing of interruption, is what is called availability management systems. Most communication technologies work on the assumption that availability is binary i.e. that users want to be available or they do not (Ljungberg 1999). A set of empirical studies (Ljungberg 1996, Ljungberg and Sørensen 1996) emphasized that this is not a valid assumption. Rather, people want to be constantly available but not for all communication. As a consequence of this shortcoming users are often forced to switch on and off the communication device to avoid unwanted interaction (Ljungberg 1999, Begole et al. 2004, Fogarty et al. 2005). This creates two kinds of problems: appropriate communication is missed as a device is turned off, and when it's turned on inappropriate communication is received.

More recent communication technologies do however support more fine-grained approaches for explicit management of availability. Begole et al. (2004), for example, refer to a set of proactive strategies of which one is to screen incoming calls or IM messages based on caller-identification. As the person who is making a phone call does not know if the recipient is present/available, it is possible to claim "plausible deniability" (Nardi et al. 2000). Such a proactive strategy of screening unwanted interaction could in a way reduce the disruptive effects of interruptions but will not prevent them from happening, as notifications of incoming messages are disruptive even if ignored (Czerwinski et al. 2000, Cutrell et al. 2001). Another explicit strategy for reducing unwanted interaction is (according to Begole et al. 2004) to use a function found in most IM systems allowing users to set their presence (e.g. away) or availability status (e.g. busy) and add some textual explanation (e.g. will be back in ten minutes). These proactive strategies may prevent unwanted interaction but may also reduce the amount of desired interruptions (Begole et al. 2004), and in addition it

can be tricky to remember to switch status when going from one mode to another.

An alterative to the explicit approach mentioned above is to rely on implicit availability management that relates to "the ways in which a person unconsciously signals to other persons in the surroundings (including also online contacts) if he/she is open to communication or not" (Harr and Wiberg 2008, p. 5). This approach relies on either automated calculation of individual availability or presence based on sensor-gathered information (e.g. Begole et al. 2004, Fogarty et al. 2004b), or on individuals determining the availability of others based on the awareness information these share through ongoing audio/video transmission, glimpses or snapshots indication (e.g. Abel 1990, Bly et al. 1993, Tang et al. 1994b, Lee et al. 1997). Begole et al. (2004) present the Lilsys system (see figure 2), making use of motion and sound detectors, and mouse and keyboard activity monitors.

Fig. 2. Lilsys sensor and data acquisition module (Begole et al. 2004)

In addition, a timer is added that allows users to override the system and set their status to the maximum unavailability level. Lilsys was integrated with the Awarenex system (Tang et al. 2001) and inherited device and calendar information from that system. Based on sensor data, the availability of the user is assessed through combinational

data from sound, motion detector, keyboard/mouse, door sensors, sound, and phone activity. The data is then interpreted and the calculated availability is displayed in the Awarenex contact list through traffic sign inspired color symbols; neutral for no inference, a yellow diamond for possibly unavailable and a red-bordered sign for probably unavailable (see figure 3).

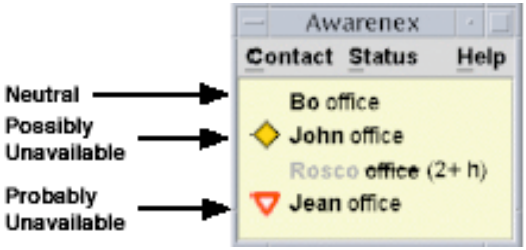

Fig. 3. The calculated availability of Lilsys users is displayed in the Awarenex contact list through traffic sign inspired color symbols (Begole et al. 2004)

Others have relied on different forms of systems for connecting offices across distance through the use of media for availability management and awareness indication (e.g. Abel 1990, Mantei et al. 1991, Dourish and Bly 1992, Bly et al. 1993, Tang et al. 1994b, Lee et al. 1997). Some relied on desktop video cameras for sharing information of the whereabouts of individuals through continuous video/audio channels (Abel, 1990, Mantei et al. 1991, Bly et al. 1993), while other systems promoted the sharing of short video glimpses (Tang et al. 1994), or still images of other people's offices (Dourish and Bly 1992, Lee et al. 1997). Even though these attempts to support implicit availability management have shown some value on a prototype level of analysis, they have not been used to any large extent in modern organizations.

2.4.5 Multitasking and Task Switching

According to Robertson et al. (2004), the most popular software system for managing multitasking is what is called virtual desktop manager systems (VDM). The most recognized VDM system is probably Rooms, a system developed by Card and Henderson (1987) based on the observation that tasks can be supported through the management

of sets of windows, each corresponding to a certain task. Working with sets of windows promotes faster task switching than if each window needs to be manipulated individually. The user is provided with several screen-sized workspaces (Rooms) that each corresponds to a task, and in each Room there are several small icons named Doors. As the user clicks on a door icon he or she enters a new Room containing another set of windows, and through an overview feature provided in the system the user can see an overview of his or her current tasks (Card and Hendersen 1987). Following Card and Henderson's work, several more or less novel systems for managing tasks have been put forward such as 3D environments, as in the Task Gallery (Robertson et al. 2000), a zoomable space as in Pad++ (Bederson and Hollan 1994), a virtual desktop based on an eye metaphor (Rao 2003), and use of time as an organizing principle (Rekimoto 1999).

There are also designs that do not replace the desktop metaphor for supporting multitasking and task switching. These systems provide alternative ways to improve the processes of multitasking and task switching in different ways (Kaptelinin 2003, Robertson et al. 2004, Czerwinski et al 2004). Kaptelinin (2003) developed a system called UMEA (User-Monitoring Environment for Activities) for supporting higher-level user activities. UMEA provides opportunities for individuals to organize documents, folders, URLs and contacts into pools related to specific activities. This enables smooth switches between the work contexts of different activities through manipulation of icons. The UMEA system supports multitasking and task switching in several ways. It helps users to get an overview of current tasks, to notice upcoming deadlines and to identify the work context of projects. Robertson et al. (2004) developed a system called Scalable Fabric based on focus + periphery as a management approach. The Scalable Fabric system (see figure 4), enables users to define a central focus area and sets of windows corresponding to other tasks are placed outside this, in the periphery. They are still visible as small icons but cannot be worked on unless brought into focus. This system also supports task switching and multitasking even if the functionality in the Scalable Fabric system is less developed than in the UMEA system.

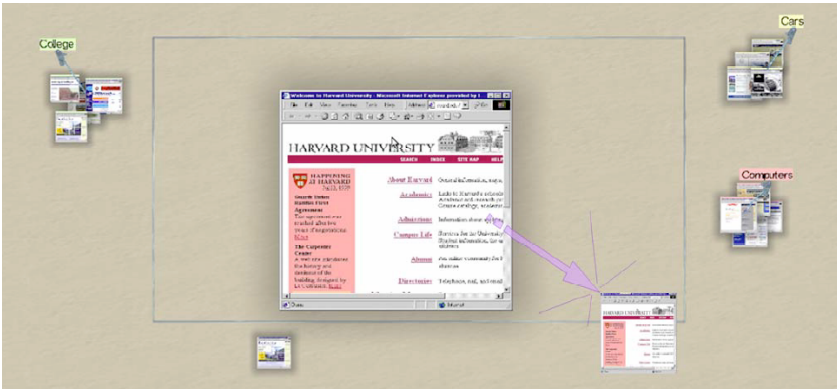

Fig. 4. The Scalable Fabric system. A system for managing tasks by either placing them in the center or in the periphery on the desktop (Robertson et al. 2004).

Other approaches for managing multiple tasks and task switching are for example reminder systems (Lamming et al. 1994, Renaud 2000, Czerwinski and Horvitz 2002), which support the task switching individual in getting back on track. Renaud (2000) support this by visualizing application activity for the user, and Lamming et al. (1994) make use of a video log as memory prosthesis. Czerwinski and Horvitz (2002) found that users typically preferred to see snapshots of their computing events instead of full video. Based on work contexts of multitasking cooperators it is easy to understand why. These systems were developed with an explicit focus on supporting individuals in recuperating abandoned individual tasks and do not take into consideration that task switching also occurs between various cooperative tasks.

2.5 Discussion of current technological support for cooperation on complex problems

Even though IT has been used in organization settings for a long time there are very few examples of widespread, widely accepted, and recognized CSCW technologies. Researchers (e.g. Schmidt 2006) have claimed that one of the reasons for this is that most systems are not based on a thorough understanding of the complexity of cooperative work and that software designers tend to base their designs on com-

mon sense understandings of cooperative processes. The result is designs that are too cumbersome to handle (Kristoffersen 1997), rigid, threatening the integrity of users, and as a consequence failing to reach their objectives (Schmidt 2006). The most striking examples were seen in the era of media spaces but also more recent CSCW technologies share this drawback. One such example is the Marratech Pro system (mPro), a desktop conferencing system supporting video, audio, shared workspaces, and chat for promoting information sharing and interaction between distributed actors. Even though the system was experienced as beneficial by users in the division of media technology (reported in paper 2 and 3), use of it is associated with initial calibration efforts (e.g. camera, microphone and speakers), reduced processing power for other computer based tasks, introduced potential threats of integrity, and in the case of some participants (using Microsoft Vista) the system would not run at all.

Most of the technologies outlined in this section are prototype systems developed to address some issue related to computer-supported cooperative work. Some attempts are reported to be somewhat successful, some are not. Even though the rationale behind deployment of prototype systems is often to test whether a certain design can support a specific aspect of cooperative work, the value of these attempts can be questioned. In a way problems are being solved, but are they actually solving the 'right' problem? If we use the attempts to reduce resumption lag after an interruptions by reviewing extensive logs as an example, it is evident that by solving one problem (smooth task switching) we are worsening another by forcing cooperators to take time to browse extensive logs of video and images. This approach of focusing on single aspects of cooperative work and single applications is not a productive way to solve the problem of striking a balance.

As will be outlined in the next chapter, the approach taken in this thesis consists of several explorations of applied procedures, including sophisticated IT use, and challenges faced in real life contexts. Even though the foci of individual explorations are somewhat specific, the sum of them provides an extended understanding of how a balance can be struck in cooperative work, what challenges cooperators face and the support needed for these processes to succeed.

Chapter 3
Theory

In this chapter the theoretical frameworks that have been predominately used in the area of CSCW and that have had an influence on this thesis are presented. As will be shown, these theories are often appropriated from other disciplines. Their value for an exploration of computer-supported cooperative work in general, and for an exploration of multitasking cooperators trying to find a balance in work in specific will be discussed. The chapter begins with a discussion of why we need theories, followed by descriptions and discussions of the usefulness of coordination theory (Malone and Crowston 1990, 1994, Crowston et al. 2006), distributed cognition (Hutchins 1990, 1995, Hutchins and Hazlehurst 1992), and activity theory (Engeström 1987, Kuutti 1991, Kaptelinin and Nardi 1997, 2006, Kaptelinin et al. 1999). The chapter is finalized by a description of how theory has influenced work of this thesis.

3.1 What do we need theories for?

A wide range of theories, conceptual frameworks and descriptive methods, springing from very different disciplines, has been used within the field of CSCW for describing settings and systems. A list of some of these attempts would include (see Halverson (2002) for a more thorough list): activity theory (Engeström 1987, Kuutti 1991, Kaptelinin et al. 1997, 1999), coordination theory (Malone and Crowston 1990, 1994, Crowston et al. 2006), distributed cognition theory (Hutchins 1990, 1995, Hutchins and Hazlehurst 1992), ethnometodology (Bentley et al. 1994, Rouncefield et al. 1994, Heath and Luff 1996), grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998), situated action (Suchman 1987). Research based on these frameworks has contributed to the area of CSCW. A number of these theories have however been more influential than others and some have gained a lot of attention for a period of time but have, at least to some extent, faded away as key frameworks for CSCW research.

The rationale behind choosing a theory is often pragmatic, i.e. we use the theory that can help us see what it is that we are interested in seeing. This view of theory is expressed by Barhelmess and Anderson (2002: cited in Halverson 2002) as follows:

> The value of any theory is not 'whether the theory or framework provides an objective representation of reality' (Bardram 1998), but rather how well a theory can shape an object of study, highlighting relevant issues. In other words, a classification scheme is only useful to the point that it provides relevant insights about the objects it is applied to.

As such, a theory is often like a pair of dark glasses that filters out what we consider as less relevant and highlights what is relevant (Halverson 2002). When choosing a theory we should choose one that can help us in doing what we have decided to do; but also, we need to be aware of the strengths and shortcomings of different theories before making an informed choice. In what follows three theories used in the area of CSCW in relation to the studied phenomenon of this thesis will be discussed.

3.2 Coordination Theory

As cooperative work is to a large extent dependent on cooperators' ability to coordinate, mesh and interrelate their individual activities

into a coherent whole, Coordination Theory (CT) is worth considering as a framework for the exploration presented in this thesis.

Malone and Crowston (1990, 1994), the founders of Coordination Theory, argued for their theory as a way of improving the quality of computer-supported cooperative work tools. A key issue for developing such support is to understand the dependencies between tasks that individuals perform and the way that the group coordinates its work (Crowston et al. 2006). While many studies of group work only describe these processes in general terms, Malone and Crowston (1990, 1994) put forward a new approach for addressing these issues, i.e. Coordination Theory. With a starting point in 1994, nearly 300 dissertations and papers have either made direct use of, or referred to the theory (Crowston et al. 2006). A theory that Malone and Crowston (1990, p. 358) describe as:

> [...] a body of principles about how activities can be coordinated, that is, about how actors can work together harmoniously.

In the paper from 1994, Malone and Crowston presented a set of examples describing similar coordination problems found in very different disciplines (e.g. sociology, computer science, economics, psychology) and analyzed them as being caused by dependencies. As such the primary reason for launching CT was to synthesize work on coordination in different disciplines (Crowston et al. 2006). What Malone and Crowston (1990, 1994) wanted to do was to show the potential in establishing connections between coordination research within different disciplines for presenting a more general, simple and coherent theory of coordination. Their first contribution was to present the following concise definition of coordination:

> The act of managing interdependencies between activities performed to achieve a goal (Malone and Crowston 1990, p. 361)

This is a definition of coordination that has received a lot of attention and has been widely used within HCI and CSCW research. Another contribution of CT was to offer a theoretical framework for conducting analysis of coordination (Crowston et al. 2006). Malone and Crowston (1994) analyzed the actions of groups as actors doing interdependent tasks, tasks that either require or produce various kinds of resources.

Actors can be customers and organizational employees (e.g. software developers), while tasks can be the development of system requirements based on the work processes of customers as well as ensuring that no conflict emerges between different requirements. In this case resources could be information about available platforms, about the customer's problem, about available programmers or system developers. As a consequence of the existing dependencies in work, coordination problems are faced that constrain how work can proceed (Crowston et al. 2006).

The main claim of CT according to Crowston et al. (2006) is that dependencies and mechanisms for managing them are general and can be found in very different organizational settings. Therefore a typology of dependencies and their respective coordination mechanism has been put forward (see Malone and Crowston 1994, p. 91). One example of such a relation is that between task and actor; for example, that an actor with certain expertise is needed for a certain task. CT suggests that these kinds of dependencies and their related coordination mechanisms should be studied and identified in a wide variety of organizational contexts. To surmount these coordination problems (e.g. managing the difficulties associated with actor-task dependency) cooperators need to take on additional work, referred to as coordination mechanisms by Malone and Crowston (1994). In the example given above of the task-actor dependency, this could imply relying on one among several coordination mechanisms, such as assigning the task to the first available actor, having a manager distribute the task to an appropriate actor, etc.

These contributions of the theory have been appreciated by a wide range of researchers active in very different settings such as software engineering (e.g. Faraj and Sproull 2000), system design (e.g. van Breemen and de Vries 2001), and business processes (e.g. Sikora and Shaw 1998). When taking the purpose of this thesis into consideration CT has provided inspiration, especially when it comes to its focus on management of interdependencies in cooperation. As such the theory and its orientation towards harmonious coordination of activities was one of the factors that influenced the decision about what research issues to address in the thesis. There are, however, some aspects of coordination theory that make it a less useful framework for the pre-

sent exploration. First of all, the theory does not focus on the role of communication and decision-making aspects of group work to any large extent (Crowston et al. 2006). Malone and Crowston (1990, 1994) acknowledge the importance of these aspects for collaborative work but they nevertheless tend to be excluded in analysis based on coordination theory. Second, cooperative work, in contrast to individual work, consists of both individual work and overhead work needed for coordinating the contributions of individuals (Schmidt and Bannon 1992, Carstensen 1996, Mintzberg 1999). Even though CT could highlight a wide range of important aspects related to the coordination of individual efforts (that is the main focus the theory), it would be unable to include and highlight individual aspects of cooperative work, or the frequent switches in between.

3.3 Distributed cognition

Distributed cognition (DCog) has been widely used within the CSCW community ever since the theory was 'launched' through the publication of Hutchins canonical book *Cognition in the Wild* (Hutchins 1995) and a set of articles (e.g. Hutchins 1990, Hutchins and Hazlehurst 1992). The DCog framework has been described as:

> [...] a new branch of cognitive science devoted to the study of the representation of knowledge both inside the heads of individuals and in the world ...; the propagation of knowledge between different individuals and artifacts ...; and the transformations which external structures undergo when operated on by individuals and artifacts .... By studying cognitive phenomena in this fashion it is hoped that an understanding of how intelligence is manifested at the system level, as opposed to the individual cognitive level, will be obtained (Flor and Hutchins 1991, cited in Nardi 1993, p 56).

DCog was developed in order to explain cognitive activities as embodied and situated in the context in which they occur. One of the ambitions of the framework is to enable, through adopting this broad focus, analysis of socially distributed and complex work activities in which a wide range of technologies and tools play an important part. As such the theory is based on the notion that we cannot understand the way a system achieves its goals by solely understanding the properties of individuals (Nardi 1993).

What constitutes the unit of analysis in distributed cognition is a collection of individuals and artifacts as well as their relation in a spe-

cific work context, comprising what in DCog is called the functional system. The aim of distributed cognition is to support system design and implementation by conducting extensive field studies (often based on ethnographic methods), analyzing problems with existing technology and work practices, and suggesting recommendations for redesign (Rogers and Ellis 1994). The framework has been applied in a wide range of contexts ranging from Hutchins' (1995) analysis of ship navigation, Hutchins and Klausen's (1996) exploration of flight deck work, Halverson's (1995) study of air traffic control, to Flor and Hutchins's (1992) study of software teams. The goal of these explorations of various functional systems is described by Rogers and Ellis (1994, p. 123) as being:

> [...] to account for how the distributed structures, which make up the functional system, are coordinated by analyzing the various contributions of the environment in which the work activity takes place, the representational media (e.g. instruments, displays, manuals, navigation charts), the interactions of individuals with each other and their interactional use of artifacts.

The representational media refers both to internal media, such as an individual's memory, as well as external representations such as various forms of computer-based and paper-based displays. The states of these representations are associated with how knowledge and information resources are transformed as work unfolds, for example by typing in a value in a computer the computer system will change its state (Rogers and Ellis 1994). Hutchins (1995) provides an example of how a ship is navigated when approaching land, showing how knowledge is shared among the cooperating individuals and how information is mediated through and across the artifacts being used, e.g. an alidade (a telescopic sighting device), a fathometer (a device for measuring water depth), or radar.

When it comes to developing an understanding of how multitasking cooperators strive to find a balance between articulation work and individual task execution the framework of distributed cognition has some potential, especially when it comes to how the approach examines the role of artifacts (internal as well as external) through which representations are embodied and the processes that propagate representations across media.

DCog, with its strength in capturing functional systems, would however have been experienced as less valuable for developing an understanding of contexts in which social interaction among individuals are related to different hierarchies of activities, e.g. participation in different projects and workgroups. For example, distributed cognition could have served the purpose well to develop an understanding of processes related to a teacher's participation in a workgroup, but would hardly be able to capture the work of teachers as part of a wide range of these cooperative formations. As an indication of this shortcoming of the theory, most research in which it has been applied is focused on well-defined and well-established coordination and cooperation practices (Kaptelinin and Nardi 2006).

3.4 Activity theory

Within the field of CSCW, as well as in related fields such as HCI, activity theory (AT) has come to play an important role for understanding and describing work practices (e.g. Kuutti and Arvonen 1992, Nardi 1996, Bardram 1998, Orre 2009), and for informing design (e.g. Raeithel 1992). According to Nardi (1996) the main strength of the theory is as a conceptual tool for making powerful and clarifying descriptions, rather than for making predictions.

The theory has three main historical sources. One is from the classical German philosophy in which Kant and Hegel introduced the concept of activity. Another source was the work by Marx and Engels who further elaborated on the concept of activity. The third source is the writings of Vygotsky, Leont`ev, and Luria, active at the Moscow Institute of Psychology (Kuutti 1991). Today the theory has gained a foothold in the western academic world and has been widely used within the field of CSCW and HCI, but also within other disciplines such as education, cultural research, anthropology, etc. (Kuutti 1991).

Activity theory offers a broad theoretical framework for making descriptions of human activity from the perspective of structure, development and context (Kaptelinin et al. 1999). The unit of analysis is the activity, always including a subject (a group or an individual), with an object or motive, using artifacts, and functioning under socio-cultural rules. According to adherents of the theory we cannot separate these components without violating the very essence of human activity. This

would be like separating sodium and chloride in trying to understand salt (Leont`ev 1978, cited in Kaptelinin et al. 1999). Two fundamental ideas provide the foundation of AT. First, the human mind materializes, exists, and is only understandable in relation to the context of human interaction with the world. And second, this interaction between human and world, the activity, is culturally and socially determined. These two ideas are what constitute the foundation on which a set of principles is based; these are object-orientedness, hierarchical structure of activity, internalization/externalization, mediation, and development (Kaptelinin et al. 1999).

Principle 1: Object-orientedness.

This principle puts forward the notion of activities as being directed towards something that objectively exists in the world i.e. an object. One example of such a relation could be a programmer's activities towards a computer program (Kaptelinin et al. 1999). A human activity can be oriented towards two different types of objects: people or things (Leont`ev 1978).

Principle 2: Hierarchical structure of activity.

The second principle of the framework describes how activities are organized into functionally subordinated hierarchical levels, i.e. activities, actions, and operations (Leont`ev 1981). The relationship between these levels is that activities always correspond to motives, i.e. they are undertaken to fulfill motives, even if we are not always aware of these (Kaptelinin et al. 1999). Actions on the other hand are goal-directed processes that we need to carry out to fulfill a motive. We are aware of the actions that we take as well as the goals that we have with our actions. Kaptelinin et al. (1999, p. 29) provides the following example:

> [...] a programmer may write a utility program needed to make his larger program work efficiently. The larger program itself might be an action with respect to a motive such as getting ahead at work.

The actions we take are triggered by our goals, and these can be broken down into several subgoals. In the creation of the utility program

mentioned above, it could be necessary for the programmer to discuss how this could best be done with a colleague. Making arrangements for achieving interaction with that colleague could be associated subgoals such as finding a time for interaction, choosing the best communication channel, etc. The lowest level of an activity is what AT terms operations. These do not correspond to a conscious goal or action but are rather driven by conditions (Kaptelinin et al. 1999). In our everyday lives we do not pay much attention to the operations that we do, we just do them. Over time, actions, after having been done several times, might become routinized and demand little effort from the individual. An example used by Leont`ev (1978) for showing this movement between different hierarchical levels of activities is gear shifting. The first time we drive a car, shifting gears is not a trivial matter. As our experience of car driving increases we find ourselves shifting gears without giving it much thought. What used to be an action has become an operation. This is however a process that can go in both directions. If we for example visit a country where we have to sit on the reverse side of the car when driving, shifting gears might demand more efforts from us as drivers and the operation of shifting becomes an action. This move back and forth the hierarchical levels of activities is an important characteristic of AT and is what distinguishes the theory from more static alternatives (Kaptelinin et al. 1999).

Principle 3: Internalization/externalization.

The third principle in activity theory is the one of internalization/externalization. Here a difference is drawn between internal and external activities and it is claimed that we cannot understand internal activities if we exclude external activities. This is due to the fact that the continuous transformation between these two modes of activities is the very basis of human activity and cognition (Kaptelinin et al. 1999). This transformation can involve making routine work explicit (i.e. an externalization), or to learn how to do something without thinking explicitly about specific details (i.e. internalization) (Kaptelinin and Nardi 1997).

Principle 4: Mediation

The fourth principle argues that external tools (e.g. computers), but also internal tools (e.g. norms and procedures), that surround us mediate activities. These tools shape the way that we interact with reality (Kaptelinin and Nardi 1997) and are often the result of other peoples' experience of trying to solve similar problems and develop tools for doing that. This prior experience is accumulated in the structural properties of a tool as well as in knowledge of how the tool should be used (Kaptelinin et al. 1999).

Principle 5: Development.

This final principle takes its point of departure in a view of practice as being reformed and shaped by historical development. As such it becomes important to see how tools are used over time and not only in single instants of use (Kaptelinin et al. 1999). Tools are not only used to solve a problem, they also carry with them a history and are the result of previous historical, social, and cultural transformations.

These principles cannot be isolated from one another but should rather be seen as an integrated system associated with various aspects of the entire activity (Kaptelinin et al. 1999). The main idea behind this set of principles is to provide the possibility to structure and guide ideas and research.

The concept of activity in Activity Theory

In AT the fundamental type of context is the activity and this activity is something that is done towards an object. This object is transformed by a subject, e.g. an individual or a collective formation, making use of tools, into an outcome. To take the context into consideration, those who share the same object of an activity need to be included as well; this is what Engeström (1987) termed community. The subject, object and community together produce the outcome of an activity. These are related to each other through mediators (Kuutti and Arvonen 1992). The tool is what mediates the relation between the subject and the object. The relation between the subject and the community is mediated by rules, and division of labor mediates the relation between the

object and the community. These components form the basic structure of an activity as shown in figure 5.

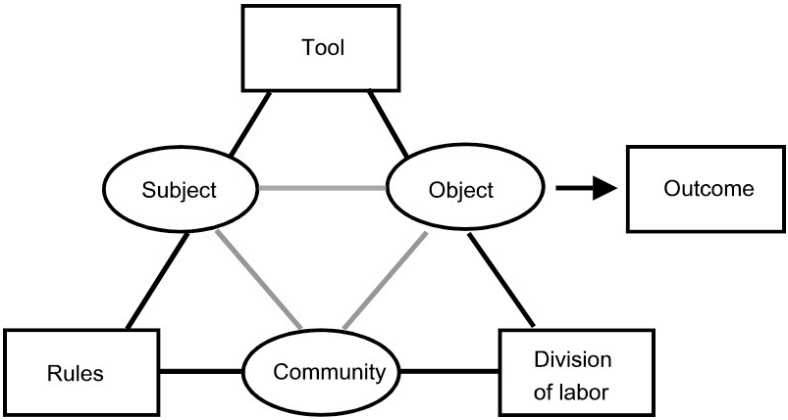

Fig. 5. Basic structure of an activity (Engeström 1987). The gray lines show the relationships between the components, while the black lines shows how these relationships are mediated.

In the beginning of the 1990s the theory was not widely accepted and many considered the theory difficult to learn (Nardi 1996). The works of Nardi (1996) and Kaptelinin and Nardi (2006), in which the theory has been made more comprehensible for novice users, contributed to the wider appreciation of the theory seen today.

For the purpose of writing this thesis, activity theory seems like a suitable approach. This is especially due to how it emphasizes the individual as a technologically empowered subject taking actions with a social context. A shortcoming of the approach, besides still being somewhat difficult to learn, is the limited support for theorizing about transformations between individual and collective levels in collaborative work that it provides (Kaptelinin and Nardi 2006).

3.5 Theoretical influences on the current exploration

The aim of this thesis is to contribute to the development of an understanding of how to strike a balance between work articulation and individual task execution in computer-supported cooperative work, with no particular ambition to further develop the theoretical frame-

works described above. The present work does, however, rely on and further develop several theoretical concepts related to the studied phenomena. It might be the case that other researchers take these redefined concepts and use them for developing theories in the future, but that is not the aim here.

Coordination theory, with its ambition of uniting researchers across disciplines with an interest in coordination, inspired to the present focus on cooperative work in the first place. Even though it is quite common that researchers make use of Malone and Crowston's definition of coordination from 1990, the popularity of the framework in CSCW has to some extent faded over the years. The main reason for not applying this framework to a fuller extent is its low support for understanding the role of communication and decision-making of group work (Crowston et al. 2006). As previously described, communicational aspects play an important part in striving for balance in computer-supported cooperative work.

DCog and AT both focus on social and physical distribution of phenomena such as cognition and agency, but also highlight the role of social context, mediation and development (Kaptelinin and Nardi 2006). This is a focus that has helped the present study to acquire a lens for choosing data gathering techniques, formulating questions, guiding observations as well as for the analysis of data. Even if no special use is made of these theories, which Kaptelinin and Nardi (2006) term post-cognitivist theories (together with phenomenology and actor network theory), they have both had some influence on the work of this thesis. Both DCog and AT have been of significant importance for CSCW research over the years, and Halverson (2002) considers one of the reasons for this popularity to be their commitment to ethnographically gathered data for understanding real life contexts and practices. Through this perspective, both theories have influenced the selection of data gathering techniques and the research approach applied in this thesis, where substantial effort is directed to understanding computer-supported cooperative work processes in specific contexts.

Distributed cognition places an emphasis on coordination by providing rich descriptions of smoothly functioning systems consisting of individuals as well as technology. But while DCog make no distinction between people and artifacts (both are considered as agents in a func-

tional system), AT consider artifacts to mediate reality for people, a reality in which people take conscious actions (Nardi 2002). As such the theory not only provides the 'system view' as seen in DCog but also complements it by including human agency. Kaptelinin and Nardi (2006, p. 235) argue that "[...] changes in both the subject and the system cannot be fully explained at the system level". Even if the system view of DCog was influential in the conduct of the studies of various instances of cooperative work in the thesis, the importance of also taking the individual subject into consideration soon became evident. In order to explore how multitasking cooperators manage to strike a balance between articulation work and individual task execution, individual intentionality becomes of key importance. The system view of DCog does not cover these processes, activity theory with its view of activity as social in character does, even if the framework provides limited support for theorizing about transformations in between individual and collective levels in collaborative work.

Chapter 4
Method

As outlined in the introduction, multitasking and cooperating individuals taking on complex problems face numerous challenges related to finding a balance between articulating work and individual task execution. Based on the reviews of previous research and supportive IT it was concluded that an extended understanding of how cooperators strike this balance is needed. In this chapter, the research objective and inspirational roots, the research approach and process, are all outlined, followed by a description of how the four studied cases have contributed to reaching the overall purpose. The objective for this chapter is to describe the methodological considerations and process that led to the conclusions presented in relation to the overall purpose. This exploration is required for expanding our current understanding of computer-supported cooperative work and to inform design of supportive IT.

4.1 Research objective and inspirational roots

This work is partly a product of who the author was on first entering a classroom at the department of informatics in Umeå. Since that time, contact with various researchers, cases, books, papers and presentations have all had an impact on the final shape of the thesis. In this section some of these sources are presented.

An early assignment as an undergraduate student was to read Edwin Hutchins' book *Cognition in the wild* (1995) in which is to be found the following fascinating description of a certain cooperative work arrangement:

> Russian legends has it that Prince Potemkin once organized a band in which each musician had a horn, but each horn could only sound one note. To play a piece, 'the players had to be extremely skillful in order to preserve the synchronic performance of all the instruments and weave their own note in the melody at the right time' (Kann 1978: 52). Playing in Potemkin's horn band was apparently an enormously difficult coordination task. Sequential control was achieved by having every musician know the plan of the entire piece and also know the place of every instance of his own note within the piece. (Hutchins, 1995, p. 198)

What was amazing about this description was not only how anyone could come up with such an idea as composing a band with one tune musicians, but also how extremely well coordinated the activities of each and every musician had to be. Of course the notes themselves might have had something to do with it, but the legend was still impressive and led to an interest to study and contribute to an increased understanding of cooperative work arrangements. This interest took its starting point not so much in the individual contributions of the cooperators, but rather in the overhead work needed to manage interdependencies in cooperation. Schmidt and Bannon (1992) highlight the relation between individual work and articulation work in cooperation, a quotation that in an excellent way distinguishes individual aspects of work from work articulation:

> Because of this interdependence, any cooperative effort thus involves a number of secondary activities of mediating and controlling these cooperative relationships. Tasks have to be allocated to different members of the cooperative work arrangement: which worker is to do what, where, when? And in assigning a task to a worker, that worker is then rendered accountable for accomplishing that task according to certain criteria: when, how, how soon, what level of quality. Etc.? Furthermore, the cooperating workers have to articulate (divide, allocate, coordinate, schedule, mesh, interrelate, etc.) their

> distributed individual activities. (Schmidt and Bannon 1992 p. 8, based on Strauss et al. 1985, Gerson and Star 1986, Strauss 1988).

This complexity of articulating work in relation to one cooperative work arrangement was remarkable, especially as work in modern organizations is characterized by multitasking, where individuals are not active in one cooperative arrangement but in several. Reports such as the following, printed in Time Magazine on the 10th of January 2006 gave a glimpse into what it could be like to work under these circumstances:

> In a revealing set of studies, a team led by Gloria Mark and Victor Gonzalez of the University of California at Irvine tracked 36 officeworkers--in this case information-technology workers at an investment firm--and recorded how they spent their time, minute by minute. The researchers found that the employees devoted an average of just 11 minutes to a project before the ping of an e-mail, the ring of the phone or a knock on the cubicle pulled them in another direction. Once they were interrupted, it took, on average, a stunning 25 minutes to return to the original task--if they managed to do so at all that day. The workers in the study were juggling an average of 12 projects apiece--a situation one subject described as "constant, multitasking craziness." (Time Magazine, 2006)

Some of the questions that emerged were: How do people do it? How do they get anything done? And as IT is considered to be one of the factors contributing to the situation, other questions emerged, such as: To what extent is IT supporting cooperation among multitasking individuals? How can we design better IT support? These are some of the questions that this thesis addresses and provides answers to. Other influences affected how the topic was approached and how the actual research process unfolded.

One of the factors that led to the advent of the area of CSCW was the shortcoming of other approaches when it came to understanding and specifying how office work was actually accomplished (Bannon 1993). Bannon (1993) for example criticizes the goal of early research (IS) of automating the office in the following way:

> Information-flow diagrams of office activities do not, in any literal sense, specify how work actually is accomplished: handling 'routine' discrepancies, bending the 'fixed' rules, contextualizing aspects of the work, etc. This does not mean that they are without any merit, but it does mean that they cannot be assumed to 'capture' office work, and serve as an adequate base for automating office activities. (Bannon 1993, p. 8)

Later Information System research however acknowledges the importance of basing design of supportive technology on a more thorough understanding of how people work (Bannon 1993). Even within the field of CSCW, some early examples of designs for cooperation failed to take actual work procedures into consideration (Schmidt and Bannon 1992). One such example is the project management tool XCP described in the following way by its designers:

> XCP is an experimental coordinator tool, which assists an organization in implementing and maintaining its procedures. Its goal is to reduce the cost of communicating, coordinating, and deciding by carrying out formal plans of cooperative activity in partnership with its users. It tracks, prods, and manages the relational complexity as captured in the formal plan, so that human resources are available for productive tasks. (Sluizer and Cashman 1984, p. 251)

This example of design gives the impression of being based on the assumption that work can be condensed into formal procedures. One of the expected benefits of XCP as reported by its designers is smoother introduction of staff members, as these do not have to learn work procedures in an ad hoc manner (Sluizer and Cashman 1984). In 1987, Lucy Suchman gave her view on the role of plans in situated action, were she views plans as resources and not as guiding principles.

> Plans are resources for situated actions, but do not in any strong sense determine its course. While plans presuppose the embodied practices and changing circumstances of situated action, the efficiency of plans as representations comes precisely from the fact that they do not represent those practices and circumstances in all of their concrete detail. (Suchman 1987, p. 52).

So even if plans and other formal procedures are considered important, technology for supporting cooperative work needs to go even further and support workers in how they go about doing their work. Hughes and colleagues (1994) present two main reasons for why ethnography has come to play such a prominent role within CSCW:

> The growing plausibility of the diagnosis that the reason why many systems fail is due to the fact that their design pays insufficient attention to the social context of work; a failure often attributed to the inadequacy of existing methods of requirements elicitation and work analysis (Hughes et al. 1994, p. 429, based on Schmidt and Carstensen 1993)

And:

> A growing awareness with the emergence of low-cost technology that the ubiquitous nature of networked and distributed computing pose new problems for design which require the development of new methods which analyse the collaborative, hence social, character of work and its activities. (Hughes et al. 1994, p. 429)

While the usefulness of ethnography for understanding the real-world character of work has been well established, the usefulness of these descriptions for system design have been questioned (by e.g. Plowman et al. 1995, and Anderson 1994). Liam Bannon (2001) gives his view on the role of ethnography in CSCW research.

> There is a debate as to the exact relevance of these studies to system design per se; initially some people viewed such studies as producing "requirements", which is far from the being the case. However, the current situation could best be characterized as one in which many in the field accept the relevance of these ethnographies in exposing the artful ways people "get the work done" in spite of breakdowns and crises of various kinds, their ability to cope with constant interruption, the ways in which local knowledge is used to shape the work in a matter-of-fact and unremarked-on fashion, the importance of "mutual awareness" in many complex work settings, the need for people to "gear into work," the interweaving of individual and collaborative work, and so on. (Bannon 2001, p. 14)

Schmidt (2006) argues that what ethnography at the moment is capable of giving to design is not direct design requirements, but rather a thorough understanding of cooperative work processes that is of vital importance as it helps:

> [...] dismantle the common-sense conceptions of cooperative work, take them apart, unpack and disclose the hidden practices of articulation work, and thus give us access – analytically and conceptually – to the intricate ways and means of the production of social order in cooperative activities... And indeed, those workplace studies that have had the strongest influence on CSCW research have been studies which did not aim at arriving at specific design recommendations for specific systems but instead tried to uncover, in minute detail, the ways in which social order is produced in cooperative work settings, whatever the design implications of the findings might be. (Schmidt 2006, p. 321)

Taking the purpose of this thesis into consideration, a research approach based on a set of case studies where ethnographic techniques are used for data gathering was a suitable research approach.

4.2 Research approach and process

Given the background presented above, this section will provide an overview of the research approach used in this thesis as well as the research process for reaching the overall purpose.

4.2.1 Research approach

Galliers (1985, 1992) and Galliers and Land (1987) put forward the notion that research methods can be categorized as being either positivistic or interpretivistic, where the former is based on the assumption that the phenomena of interest can be studied objectively and rigorously. Further, any intervention made by a researcher must be of such a nature that only the experimental variable is altered, with contextual factors kept constant so that predictive power and replicability is secured (Braa and Vidgen 1999). In comparison, the interpretivist considers the strive for objectivity as inappropriate due to the fact that different humans will interpret the very same situation in different ways. Instead, the interpretivist approach strives to develop an understanding of the meanings that humans make use of in making sense of their lives (Schutz, 1967). While positivists are striving for predictions, the goal for interpretivists is to understand (Braa and Vidgen 1999). Blaikie (2000) provides a more detailed description of the interpretivist's view on the social world:

> Interpretivists are concerned with understanding the social world people have produced and which they reproduce through their continuing activities. This everyday reality consists of the meanings and interpretations given by the social actors to their actions, other people's actions, social situations, and natural and humanly created objects. In short, in order to negotiate their way around the world and make sense of it, social actors have to interpret their activities together, and its meanings, embedded in language, that constitute their social reality. Blaikie (2000, p. 115)

Braa and Vidgen (1999) further argue that a researcher applying either one of these approaches will inevitably cause interventions and as a consequence unexpected outcomes. Causing change by interventions and learning from their effects is the purpose of applying an action research approach (Whyte 1989, Stringer 1996). Change in combination with understanding (interpretivism) and prediction (positivism) are the dimensions included in Braa and Vidgen's model (see figure 6)

outlining different ways to conduct empirical research dependent on the intended research outcomes (Braa and Vidgen 1999).

Due to the focus of the present research, where improved understanding of computer-supported cooperative work is sought, the interpretivist approach, often through applying some sociologically informed method such as hermeneutics (Palmer 1969), phenomenology (Schutz 1976), or ethnography (Hammersley and Atkinson 1983, Atkinson et al. 2001), is preferable (Braa and Vidgen 1999).

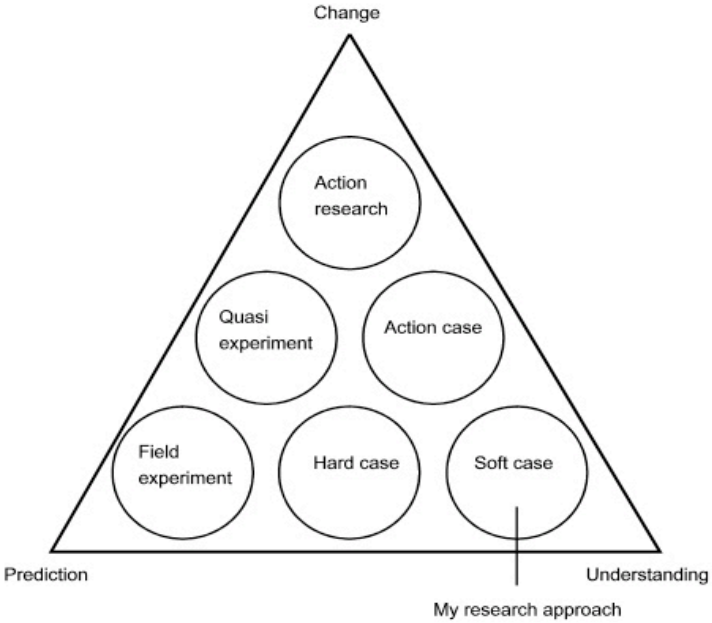

Fig. 6. Method location model where various research methods are placed in relation to intended research outcomes (Braa and Vidgen 1999, p. 32)

In the model presented above the current research process belongs in the 'soft case' circle due to its emphasis on gaining understanding of the studied phenomena through conducting several case studies based on ethnographic research methods. In the field of CSCW, such research methods have been used for some time for capturing the sociality of work (Harper 2000, Bannon 2001) and the work presented in this thesis is no exception. As mentioned in the brief description of the

research field of CSCW (section 2.1), design of supportive technology for cooperative arrangements should be based on a thorough understanding of real world cooperation arrangements and as shown by the wide range of CSCW researchers having applied its methods (e.g. Nardi and Miller 1990, Wiberg and Ljungberg 2001, Pettersson et al. 2002, Crabtree et al. 2004, Juhlin and Weilenmann 2008, Orre 2009) ethnography is suitable for this purpose. Hammersly and Atkinson (1983) describe ethnography as follows:

> We see the term as referring primarily to a particular method or sets of methods. In its most characteristic form it involves the ethnographer participating, overtly or covertly, in people's lives for an extended period of time, watching what happens, listening to what is said, asking questions—in fact, collecting whatever data are available to throw light on the issues that are the focus of the research. (Hammersley and Atkinson 1983, p. 1)

Adherents of ethnography take as their guiding assumption that any group of people that interacts with each other over time will develop a culture, and that the best way to understand this culture is to be inside it (Mason 2002). Traditionally, anthropologists applied ethnography when they made participant observations of social ensembles for extended periods of time and it is an approach suitable for inquiring into cooperation and patterns of interaction (Hammersley and Atkinson, 1983). Ethnography has an open–ended approach to what should be found in the analysis of work and is based on the belief that it is difficult to foresee which elements of the studied phenomena will prove to be of value, interest and importance (Randall and Rouncefield 1996). One of the strengths of ethnography is how it helps unravel the sociality of work, the tools and technologies used in the setting for developing an improved understanding of the studied phenomenon. Even though an ethnographic research method has been applied throughout the present research work, there is no claim that these are fully-fledged ethnographic studies (such as the ones conducted in traditional anthropology). Rather, a set of interpretative case studies was conducted through relying on ethnographic methods.

The overall approach applied in this research to reach the goal of the thesis is of an interpretative nature, where four instances of cooperation have been explored through ethnographic techniques. Each and every of these cases has provided valuable input for reaching the

research aim and for understanding the process related to striking a balance in computer-supported cooperative work.

4.2.2 Research process

While it is quite common that researchers occupied with exploration of a certain phenomena try to delimit the cases in which the phenomena exist, the approach here has been to study the very same phenomena, but in different settings and from different perspectives (these settings are discussed in the end of this section).

Ethnography often relies on participatory observations for data gathering, but a wide range of alternative research techniques are also commonly used, such as interviewing, collecting and interpreting visual materials, analyzing spoken discourse etc. (Atkinson et al. 2001). When it comes to participant observations, what it means to be a participant has changed during the last decades due to the advent of the Internet and the occurrences of cooperative work arrangement that is taking place via the web of interconnected computers (Patton 2002). One of the cases in this thesis was at least partly studied through observations via the Internet (the e-corridor case), and in the same case a number of interviews were conducted through an internet-based videoconference application. To rely on several data gathering techniques is beneficial for understanding work procedures (Borghoff and Schlichter 2000) as it is likely that the weaknesses of one method will be corrected by the strength of another (McGrath 1993). This is one of the reasons why various methods for data gathering have been applied throughout the research process.

4.2.2.1 Participant observations

The most characteristic data gathering technique in the ethnographic approach is participant observation (DeWalt and DeWalt 2002, Patton 2002). In real practice participant observations often constitute one of several methodological components in an ethnographic approach (Mason 2002). Becker (1958) describes the task of the participant observer as follows:

> The participant observer gathers data by participating in the daily life of the group or organization he studies. He watches the people he is studying to see what situations they ordinarily meet and how they behave in them. He enters into conversation with some or all of the participants in these situations and discovers their interpretation of the events he has observed. (Becker 1958, p. 652)

Given this definition of the technique, researchers conducting participant observations are required to possess certain competencies such as "[…] take roles which are effective in the setting under study". (Burgess 1982, p. 45). However, according to Schwartz and Schwartz (1955) the participation level of the inquirer could range from active to passive, where the passive observer interacts as little as possible with the setting and individuals active in it. In terms of the continuum provided by Schwartz and Schwartz (1955), participation was active in the first study and more or less passive in all the others.

In comparison to interviews, participant observations have several advantages. First, through direct observation the researcher can develop a direct understanding of the context of the social setting, which supports the development of a holistic perspective. Second, by basing an understanding of a setting on firsthand experience and being less reliant on the conceptions of others, the researcher can be more open and discovery-oriented. Third, direct observations enable the researcher to see things that would not be reported in interviews due to how they have become 'invisible' to the individuals active in the context. An example of such an invisible occurrence could be routines that have been followed for such a long time that they are taken for granted. Fourth, through observations a researcher can see things that individuals are unwilling to talk about in interviews. Fifth, direct observation enables moving beyond the perceptions of others by adding the perception of the researcher. This provides a more comprehensive understanding of the social setting than if relying on interviews alone. Sixth, by having hands-on experience of a social setting the researcher can add impressions and feelings to the data analysis phase (Patton 2002).

Participant observation has played a key role in achieving the purpose of this thesis, especially because of the way in which it can unravel aspects of cooperation that are not easily captured through secondhand experience. Conducting participant observations is however

anything but trivial. A documented drawback of applying the technique is that it is time consuming (Patton 2002). Another drawback is related to difficulties in documenting observations. As a passive observer one should interfere with the studied processes as little as possible, which becomes rather difficult when taking photos and writing down notes. The researcher should try to blend in as much as possible and make preparations to avoid being considered as an evaluator.

The observation conducted in the e-corridor was of a particular nature due to the fact that participation was from a remote location and there were aspects of the work that could not be observed, aspects such as private conversations between subjects or encounters that took place outside the virtual environment. For remedying this shortcoming numerous interviews where conducted as part of the same study and specific questions regarding these issues were asked.

4.2.2.2 Interviews

Interviewing is one of the most widely used methods in qualitative research and is often seen as the golden standard of qualitative research (Silverman 2000). Interviews can be conducted in many different ways and Patton (2002) presents three alternatives, all with different strengths and shortcomings: the informal conversational interview, the general interview guide approach, and the standardized open-ended interview. The first and second were adopted for the present work.

The informal conversational interview, or as it is also called "ethnographic interviewing" (Patton 2002, p. 342), is the most open-ended form of interview. It offers flexibility and enables the researcher to ask questions based on observations made or whatever he or she considers as most appropriate. The approach is dependent on the researcher being present in the actual social context for a relatively long period of time (Patton 2002). Documenting these interviews is somewhat problematic due to how questions are asked 'on the fly' and it is according to Patton (2002) quite common that documentation is made afterwards and in the refined form of new insights. The strengths of the informal conversational interview are considered to be how it supports flexibility and responsiveness in relation to situational changes.

In many ways the approach has many resemblances with the technique of contextual inquiry (Beyer and Holtzblatt, 1998), a technique that has been considered a compromise between conducting interviews and participant observations. The way that the interview form has been used in the present work is for establishing a contextual understanding of what it means to be an actor within the studied social context, which was found to be very useful for developing general interview guides. It was also helpful for making follow-up questions as, for example, in the e-corridor study (paper 2 and 3), where several months were spent in the virtual environment after having conducted the interview guide based interviews. A final benefit of the ethnographic interviews experienced during the study at Bilfrakt.se was how the dispatchers' use of IT could be seen and at the same time questions made. This enabled the development of an understanding related to how IT supported dispatchers in their work. Without actually seeing this in practice it would have been difficult to make sense of their statements in interviews and ask relevant questions. In all instances of ethnographic interviewing the observer started out by explaining the reason of his presence, what would be done with the data, and what was being studied.

The general interview guide approach (Patton, 2002) has been used in all the studied cases and consists of the development of an interview guide list that is used in interviews. This list serves several purposes of which the most significant is as a guarantee that the same questions are discussed with all respondents (Patton 2002). The researcher does not have to strictly follow this list of questions, on the contrary it is possible for the interviewer to elaborate within the questions that the guide consists of. This is beneficial for maintaining a productive flow in the dialogue between inquirer and respondent. The main benefits experienced with this approach are how it both provides opportunities to follow a pre-set line of questions while at the same time enabling a more discursive form of conversation than would be the case with standardized open-ended interviews (Patton, 2002). In all case studies the set of questions was generated after having experienced the cooperative work arrangement through observations, or after applying ethnographic interviewing for a longer or shorter period of time. This was found to help in avoiding illogic and irrelevant ques-

tions, which could potentially threaten the flow of interviews and the creation of a productive atmosphere. Other measures that were taken for creating such an atmosphere and for preventing dishonest responses were thoroughly informing respondents about the reason and structure of the interviews, offering respondents a view of the transcriptions before analysis, and offering them final versions of all papers based on the study in which they had participated.

All interviews conducted based on the general interview guide approach were recorded and transcribed by the author personally. The main reason for this was to avoid additional interpretations as well as for shortening the analysis phase (the process of transcribing runs in parallel with the first analysis efforts). These transcripts were then used for further analysis and for providing illustrating excerpts in papers. In the e-corridor case some interviews were conducted across distances through the use of a recording function provided by the application. These recorded sessions were later transcribed in a similar way as the other interviews were.

4.2.2.3 Other applied data gathering techniques

As these techniques have played a minor role in the research process they are presented relatively briefly below.

Data logging, in the e-corridor study data logging was used as a method for generating data on degree of activity within the population. This was made possible due to a history collection tool (Parviainen et al. 2004) that enabled the collection of usage data regarding activity in a public chat function for one month. This method was not used directly for targeting the specific research question but was rather used for identification of those individuals that were most active in the public chat, which was later used for selection of respondents for interviews. During one month, 3197 contributions were made by a total of 19 active individuals in the public chat. The actual selection of respondents was based on professional roles, attendance, and activity level.

Survey study, in one of the papers included in this volume (paper 3) the exploration was based on two different studies, one qualitative (observations and interviews) and one quantitative (a survey study).

The author of this thesis conducted the qualitative study but was not involved in the execution or analysis of the quantitative study. At the end of a course at LTU (Luleå Technological University) students were provided with time during a lecture for filling in a questionnaire and rating their agreement on a set of statements on a 7-point Likert scale (strongly agree – strongly disagree). Students were also asked to provide an answer to the question of whether they would prefer to have chat or audio in combination with video on a course and to explain why. 105 students were involved in the course of which 82 responded to the survey, the result of this survey study is presented in paper 3 where most emphasis is assigned to the qualitative feedback provided by the respondents.

Document analysis, in the study reported in paper 6, document analysis was used for data gathering, in addition to other techniques. It is not uncommon that analysis of documents is included in an ethnographer's attempts to understand a social context (Hammersley and Atkinson, 1983) and in this case a set of documents describing administrative work processes and IT-use of teachers was used as a source.

4.3 Analysis of data

After having conducted a study influenced by ethnography the researcher is in possession of vast amounts of qualitative data taking various forms. The analysis phase is of vital importance in reaching the objectives of the study (Mason 2002). On one hand, if what the researcher is looking for in an empirical investigation is too tightly specified it could happen that influential aspects, that were not assumed to be influential prior to the study, could be overlooked. On the other hand, if what you are looking for in a study is specified to a very low level of detail it could be the case that no coherence in the gathered data exists at all.

In the empirical explorations the overall research question was kept in mind, but when it comes to case specific research questions the approach was rather open and these have in many cases emerged during the actual study, when transcribing interviews, or during interpretative reading. This inductive way of working has many resemblances with how explorations and analysis unfolds within Grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998) where the re-

searcher systematically analyzes data searching for theory development. Influence of grounded theory on the analysis of data following a soft case approach is not uncommon (Braa and Vidgen 1999), even if this influence did not go as far as theory development but is limited to entering the field of investigation with few preconceptions and allowing ideas, patterns, and findings to emerge from data.

The cases were approached with the ambition of exploring mechanisms for management of collaborative multitasking in computer supported cooperative work. The observations and interviews generally focused on how individuals managed cooperative work, what challenges they faced, and how technology supported them in their work. After having gathered, or while gathering, vast amounts of data the analysis phase was initiated by looking for patterns, themes and categories in the material. This phase is called interpretative reading by Mason (2002). After having gone through the material several times and having reached a point where no new patterns emerged a decision was made, often in dialog with research advisors and always in 'dialog' with the overall research question, on which theme to concentrate on in the next step of analysis, categorical indexing (Mason 2002).

Categorical indexing is a technique used to "[...] focus and organize the retrieval of sections of text, or elements of data, for the purpose of some form of further analysis or manipulation" (Mason 2002, p. 151). Data was looked for (e.g. quotes, observation notes etc.) that were related to the chosen theme and these sections were indexed by using a highlighter pen and making notes. This process of categorical indexing often partly overlapped with the process of interpretative reading, even if several of the indexed categories were later discarded in analysis. After having indexed the relevant categories and identifying a key theme related to the overall research question, the next phase consisted of relating this to existing concepts, theories or models within CSCW. After having thoroughly grounded the key theme in existing research the documentation process was initiated. The specific final steps of analysis that formed the basis for the papers included in this thesis are outlined below.

In *Exploring the Concept of Group Interaction Through Action in a Mobile Context* (paper 1) use was made of the CSCW-framework model (see figure 7), that slightly modified provided valuable support

for developing an understanding of the cooperative processes of the hunters.

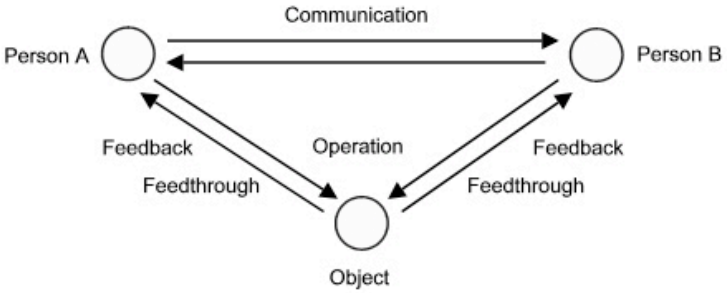

Fig. 7. The CSCW framework (Dix and Beale 1996) shows how collaboration is managed through interaction as well as manipulation of a shared object.

In *Lost in Translation: Investigating the Ambiguity of Availability Cues in an Online Media Space* (Paper 2) we based our analysis on three different work modes in modern work i.e. individual work, co-located work and virtual collaboration.

In *A Comparison of Chat and Audio in Media Rich Environments* (paper 3) two instances of analysis were undertaken. The first was based on qualitative data and was influenced by the overall research question of the paper i.e. to compare the respondents (staff at a university department) experienced utility of chat and audio after having used an online media space for a period of time. The second analysis was of a quantitative nature.

Unpacking the Social Dimension of External Interruptions (paper 4), is not an empirical paper and no data was gathered or analyzed.

In *The Survival of the Social: Understanding Interaction Foraging Behaviour in Highly Distributed Professional Social Networks* (paper 5) data was analyzed based on the theory of information foraging and its key concepts (Pirolli et al. 1995).

In *Being Virtually Everywhere: An Exploration of Teachers' Multitasking in a Hybrid Ecology of Collaboration* (paper 6) the analysis of data was conducted collaboratively involving both authors. With the overall research question in mind, data was indexed individually and later collaboratively organized into a set of key themes. In the process

a version of the affinity diagram technique (Beyer and Holtzblatt 1998) was applied.

To sum up, taking the overall purpose of this thesis into account an approach for analysis that is open and more inductive than deductive was found to be an appropriate choice.

4.4 The four cases: brief descriptions

Four cases were studied for gathering empirical data related to the overall research objective.

4.3.1 Cooperative bird hunting

The first case consisted of a cooperative arrangement formed with the purpose of hunting birds. This could seem like an odd choice due to the conceptual distance to the contexts that are traditionally associated with cooperation, multitasking and the use of sophisticated IT. The reasons for selecting the hunting activity as a departure for the thesis work were several. First, the author had domain knowledge and prior experience of the activity and had always been fascinated by how smooth coordination is achieved among these hunters. Second, in most situations of cooperative work in organizational domains the cooperative activity spans both time and distance, which makes it more difficult to follow. This case provided opportunities to follow several cooperative tasks (if each hunting session is considered as one) from beginning to end. Third, studying existing practices, even though these contain limited use of IT, is an accepted approach for finding the place for technology in a later stage. Fourth, when hunting, hunters are not involved in other cooperative activities. This enabled focused data gathering and interpretations of the activity.

The hunting group consisted of four hunters who spent a weekend of hunting in the forests located outside of the village Lövånger north of Umeå in Sweden. The activity was structured as shown in figure 8.

The hunters form a shooting line (spanning a total width of 60-160 meters depending on the density of the vegetation) and move through the terrain in a decided direction, hoping to find some prey (e.g. capercailzies and black grouses). The hunters coordinate by placing the hunter with most terrain knowledge in one end of the shooting line

and call on the other hunters to coordinate their actions in accordance to him through a chain procedure where the third hunter acts in relation to the second etc.

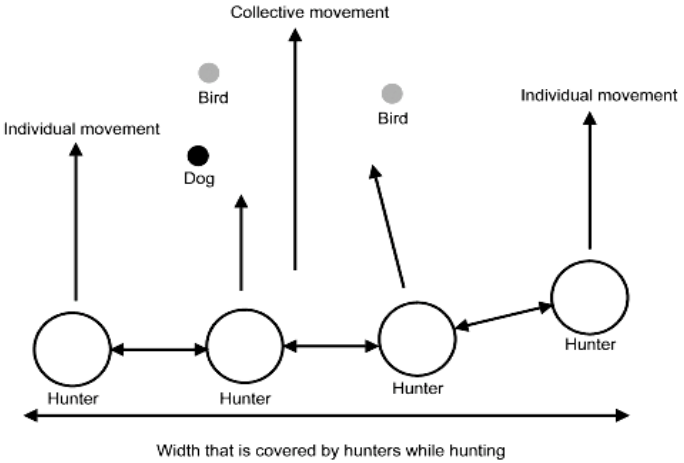

Fig. 8. Descriptive model of the cooperative arrangement of bird hunting (Harr 2002)

Due to prior experience of the cooperative activity and familiarity with the overall structure of the activity, it was possible to focus specifically on the articulation work of hunters. Extensive field notes were taken about the behaviors of other hunters while walking through the terrain and difficulties associated with articulating the individual activities were experienced directly, which was something that provided valuable input for setting up an interview guide for the interviews that followed. Due to how hunters strove to be as silent as possible when moving through the terrain it would not have been possible to develop the same understanding of the activity if for example applying the shadowing technique (see e.g. Gonzalez and Mark 2004, Mark et al. 2005) or some other form of passive observation (Schwartz and Schwartz 1955). Relying solely on interviews would have made it difficult for the respondents to communicate the implicit aspects of articulation work that were noted during the observations. In total 15 hours were spent as a participant observant and three interviews conducted, each lasting 30-45 minutes. The gathered data was later analyzed and the study resulted in the first paper included in this thesis.

4.3.2 Cooperation in a research and educational context

The second study was conducted in the research and educational department CDT (the Centre for Distance-spanning Technology) at Luleå University of Technology (LTU). The department employed 14 males and 2 females, and people active at the department had developed Marratech Pro (mPro), a conferencing tool for real-time interaction over the Internet. Research work conducted at the department is led by several project leaders and is arranged in a number of projects forming a network of more or less coupled cooperators as an employee often participates in several parallel projects.

This case was chosen due to the organization's high reliance on technology for managing work, specifically cooperators use of an ongoing media space session (see figure 9).

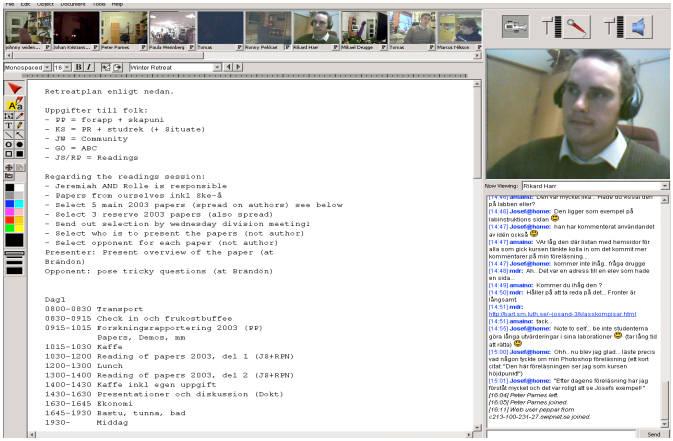

Fig. 9. Screenshot of the mPro interface taken during a meeting. The large field on the left is where the minutes are collectively written, on the lower right corner the public chat is seen.

The case also represented the type of context that is commonly associated with the problems of modern organizations mentioned in the introduction (i.e. work fragmentation and interruptions).

The first initiative was to join the e-corridor, observe how the system was used and to develop a feeling for the purposes that it served for its users. Observer participation in the e-corridor spanned approximately six months and consisted of keeping the system running

and making spot checks on a daily basis, asking questions and taking notes. The data gathered during this period was valuable in itself, but it also strongly influenced development of the interview forms used later. Before conducting interviews a data-logging tool was used (see Parviainen and Parnes 2004) for the selection of respondents. This selection was based on professional role, degree of attendance and activity in the public chat provided by system.

Ten respondents were selected for interviews; some were conducted at LTU and some through mPro. Interviews lasted for 45-90 minutes and once they had been conducted observer participation continued in the e-corridor for some time to make follow-up questions. Part of a conversation that followed having asked such a questions is shown in figure 10. The excerpt has been translated from Swedish to English and grammatical errors have been corrected.

[11:18] rharr: Hi Paul. Can I ask you why you have mPro running at work when you are working from home? Is it okay if I use your answer in our paper?
[11:18] Paul: to show that I am not there
[11:18] Paul: so that people do not have to search there
[11:19] rharr: but you can see that when you are at home?
[11:19] Paul: Plus that I keep track of what is happening in my office (even if today the camera is directed wrong)
[11:19] Paul: yes but only when I am here
[11:19] Paul: recently I wasn't
[11:19] Paul: and you can use my answer
[11:19] Paul: always

Fig. 10. A part of a conversation with one of the participants in the e-corridor. The researcher was interested in finding out why he had mPro running at work when working from home.

Data gathered during this longitudinal study was later analyzed and resulted in the publication of paper two and three in the thesis.

4.3.3 Cooperation in logistics

Involvement in the Process IT Innovations project led to contact with the logistic company Bilfrakt.se that plays an active part in the project. A meeting with representatives from the company was arranged dur-

ing which we received permission to study the coordination of vehicles. After having heard about the considerable amounts of interaction that was needed for managing the network of vehicles we considered this as an appropriate case to explore interaction search behavior in a highly distributed social network of professionals.

The study was started by spending several days in the office from which the dispatchers coordinate the network of vehicles, An attempt was made to establish some notion of how the coordination of trucks was managed, what the work situation of dispatchers looked like, how they interacted with drivers, which technology they used, etc. During those days frequent questions were asked and extensive field notes taken in order to understand the procedures and rationale behind the observed behavior. A high frequency of interaction, use of various IT-applications and sources of information such as code lists, binders, maps etc characterize the work context of dispatchers, as seen in the picture below (see figure 11).

Fig. 11. A dispatcher involved in a conversation with a driver surrounded by various information sources and communication channels.

Based on these observations an interview guide list was created and four interviews with dispatchers were conducted. The interviews lasted from 45-90 minutes and analysis of data was based on the information foraging theory (Pirollo and Card 1995). In the analysis phase issues were often encountered that could not be understood, forcing contact with the dispatchers at several other times to making

follow-up questions. This study resulted in paper 5 that was presented at the ECCE 2009 conference in Helsinki.

4.3.4 Cooperation among teachers

The senior high school studied is located in Northern Sweden and had in 2008 about 1100 pupils, and 140 teachers organized in approximately 10-15 workgroups. The school provided several CSCW-systems used for teacher-teacher cooperation even if their main purpose was to support teacher-pupil interaction and administrative work of teachers.

Before initiating the study some familiarity existed with the cooperative multitasking layout of teachers' work, the parallel use of several CSCW-systems, and that some problems had been experienced on several organizational levels in relation to the usage of these. The study was started by following a teacher for three days in order to develop a general feeling for what it was like to work at the school, more specifically how much teachers cooperated with each other, what this cooperation looked like, which role technology played in the process, etc. The initial strategy of relying on observations for data gathering was to a large extent abandoned due to how teachers spend a large proportion of their working day in classrooms with no involvement in cooperative work activities. The observation technique applied was too inefficient in this specific case and alternative techniques were turned to, i.e. interviews and document analysis for data gathering. The interviews were conducted with seven teachers and two technical support persons (TSP), experts on the technological support available at the site. All interviews were conducted at the respondents' workplaces and lasted 45-90 minutes. Teachers were interviewed individually, while the technical support persons were interviewed together. The teachers were asked about their everyday work in general, with a specific focus on cooperative processes and IT use, while interviews with the TSPs focused on previous and current IT-support for collaboration at the school. All interviews were recorded and transcribed by the author of this thesis.

Chapter 5
Results

In this chapter a summary of the results of the individual papers of this thesis is presented.

5.1 Exploring the concept of group interaction through action in a mobile context

The first paper reports empirical data gathered during a short ethnographic field study of cooperation among hunters. The objective of this study was to explore and provide rich descriptions of how a hunting group secure coordination in the process of hunting.

The paper describes the cooperative process of a bird-hunting group and how the group secured smooth and efficient coordination. The paper adds to the current body of research within the areas of awareness and coordination research by providing a rich description of an empirical case in which a cooperative formation manages coordination on a complex task without threatening the overall efficiency of the group or the involved individuals.

One contribution put forward in this paper is that the coordination process is to a large extent based on frequent non-verbal communication such as gestures, signals and most of all implicit communication (such as feedthrough of taking actions). It was further observed how smoothly hunters made switches in focus between their own individual activities and taking part in overhead efforts related to coordination of the overall activity. The paper shows how cooperators adapted their own behavior in accordance to their fellow hunters by making their own actions visible or by acting on synchronously and asynchronously, deliberately and undeliberately shared feedthrough from others. In the following figure we can see an instance of articulation work during a hunting session (figure 12).

Fig. 12. Articulation work during a hunting session

The hunter closest to the camera reaches a road and decides to wait until the other hunters arrive to prevent uncoordinated action. As another hunter shows up in the upper part of the second image the two hunters establish eye contact. The next step is to continue the cooperative activity, this step is taken by the hunter closest to the camera as he points forward signaling that it is time to continue. This is an example of explicit informal communication in the forest but also of how hunters take measures to secure shared awareness in the formation.

With a basis in the observed importance of informal (non-verbal) and implicit communication for the coordination process and the frequent switches in focus between individual task execution and articulation work, the next step was to move over to an organizational context where a larger range of technologies for interaction were used by cooperating and multitasking individuals.

5.2 Lost in translation: Investigating the ambiguity of availability cues in an online media space

This paper reports a longitudinal study of an online media space addressing the issue of availability management in an interaction intensive organization. Based on a qualitative study, ranging for approximately 6 months, we focused on how availability was managed by cooperators active in the context.

While previous research in the area of availability management have to a large extent focused on ways in which individuals apply explicit availability management strategies to indicate their availability status to others, we decided to focus on more implicit ways of signaling personal availability status to others, as well as the relation between these availability management strategies in a real-life setting.

Conducting this study was indeed challenging. This was primarily due to the fact that participants of the e-corridor were distributed and participated from different sites and organizations. This challenge was solved by relying on a combination of data gathering techniques i.e. extended participation in the virtual e-corridor for a period of 6 months, followed by qualitative interviews and follow-up questions.

The paper derives some important findings for availability management research and CSCW. One finding was that extensive virtual cooperation enabled development of common ground related to implicit availability management techniques and strategies. This is beneficial for supporting a smooth flow of interaction and work within an organization by for example reducing disruptive effects of interruptions. Following establishment of a common ground for implicit availability management, several side effects, such as an increased workplace awareness and a more 'face-to-face interaction'- like way of working together in which availability is highly dynamic, constantly changing and situational, were observed. Another set of findings concerns making estimations of others' availability, mostly based on broadcasted video from offices and public spaces and the public chat supporting a continuous flow of informal communication and acting on these. The findings show that people make decisions of how (not if) to approach a colleague based on synchronous and asynchronous information received through various channels, but also based on communicational preferences, the errand and social relation.

As shown in this paper various communication channels have different properties, are used in different situations and for different reasons. In the next paper these properties are explored further and a comparison is made between two of the communication channels available in the mPro system, i.e. audio and chat.

5.3 A comparison of chat and audio in media rich environments

The third paper reports empirical data collected from two studies (one quantitative and one qualitative) of informal group communication in a naturalistic organizational context. The purpose of the paper was to compare audio and chat as communication media and to challenge the hypotheses that chat is a low bandwidth alternative that is only used when audio communication is not available. In addition, the study also presents data on usage patterns, preferences and attitudes of users in relation to their use of these channels. The paper adds to the current body of research within the area of CSCW and HCI by challenging the bandwidth hypothesis and showing instances of cooperative work in which the richest media isn't necessarily the best and that chat is considered to have a future even in media rich contexts.

We found several reasons why the asynchronous communication channel of chat was preferred for informal communication in the organization. First, public chat supported the multitasking layout of work by enabling participants to view chat history and update themselves on what people had been discussing and doing in the past. Second, the chat was considered as less intrusive than alternative communication channels due to how it didn't demand an immediate response from the targeted individual. Third, chat can both be used for synchronous and asynchronous interaction and allows frequent 'stop and go', i.e. the channel does not tie the interacting parties down and provides flexibility when it comes to intensity of interaction. This is a beneficial characteristic for multitasking individuals and their organization. Fourth, the chat also provide opportunities for developing a sense of the current status of each other i.e. whether or not they are busy, what they are working on, with whom they are working and their mental state (e.g. stressed or relaxed). Based on this estimated status

(presence or availability) of colleagues, individuals behave in different ways.

As indicated by the findings mentioned above, chat is preferred over a 'richer' alternative i.e. audio in many situations and for several reasons. The most important one is to support individuals in developing an understanding of the activities of others, which provide opportunities to reduce disruptions and secure a smooth flow of work. As a consequence the findings of this paper speak in favor of providing cooperators with not only media rich alternatives, but also less rich media due to how they support several important aspects of cooperative work. The next paper further explores the effects of and strategies for managing interruptions.

5.4 Unpacking the social dimension of external interruptions

With a starting point in identified shortcomings of previous interruption research, this paper explores the social dimension of external interruptions of human activities. Within the areas of HCI and CSCW, interruptions have almost exclusively been addressed in experimental studies of individual activities. As organizations are increasingly reliant on cooperative formations for getting work done it is essential to widen the scope of analysis of interruptions to include consequences of interruptions that reach beyond the individual.

The findings of this exploration emphasize that even if the impact of an interruption on the individual task is important, interruptions typically do not stop there. Interruptions of an individual task could also create 'collateral disruptions' i.e. affecting individuals present in the same place as the target of the interruption. If someone is involved in interaction, especially if interacting synchronously, an interruption might create 'freezing' of the interaction. An interruption targeting an individual involved in cooperation can cause the interrupted individual to 'drop the ball' and thereby disrupt the cooperation. Lastly, an interruption caused by another person always happens in the context of the social relation between the one being interrupted and the one responsible for the interruption.

The paper adds to the body of research concerning interruptions and interruption management by providing 'evidence' for the need to

include social aspects into the analysis of these phenomena. A set of 'ripple effects' are identified and put forward (i.e. location, communication, cooperation, and interpersonal relation) for strengthening this claim. The paper also adds to the current body of interruptions research within the field of CSCW by providing a discussion concerning methodological challenges, and considerations for the design of systems for interruption management.

The importance of including social aspects for understanding cooperative procedures also guided the process described in the following paper where the importance and challenges of social interaction search behavior is emphasized.

5.5 The survival of the social: Social interaction foraging in highly distributed professional social networks.

This paper takes as point of departure previous research into distributed work and information foraging theory to explore interaction search behavior in highly distributed social networks. Being able to locate other cooperators for establishing interaction is a crucial aspect of computer-supported cooperative work due to the extensive interaction needed for work articulation. Previous research on workplace interaction has mainly focused on informal and formal aspects of workplace interaction and there are very few studies with explicit focus on how individuals go about searching for each other and the rationale behind this behavior. Even though the main focus of this paper is on interaction search behavior we were also interested in finding out to which extent the information foraging theory could be helpful in the exploration. The empirical study was conducted in the area of logistics.

It was found that interaction search behavior is a complex process best described as a one of constant negotiation. When searching for interaction the availability of others is important, but the result of previous negotiations, estimated competence of others and network maintenance are also considered. Interaction search behavior is also a social process in which cooperators, if they can, help each other in satisfying their interaction needs.

Based on these findings, the paper outlined design implications speaking in favor of technology supporting multiple, integrated, and open channels that allow lightweight and effective negotiations. But

also to provide cooperators with technology that can help create a 'balanced social network' in which all peers are actively engaged i.e. technology that includes functionality to provide user with overviews of social network interaction histories.

As described in previous parts of this thesis, individuals in modern organizations typically are involved in several simultaneously running cooperative endeavors and face, as a consequence, the challenge of striving for efficiency under a severe load of interaction and information. The next paper explores these issues further.

5.6 Being virtually everywhere: An exploration of teachers' multitasking in a hybrid ecology of collaboration

The last paper reports an empirical study of a hybrid physical/virtual ecology of cooperation at a senior high school in Sweden. The aim of the study was to investigate teachers' strategies for handling multiple cooperative activities and vast amounts of information and interaction. The school is a massively cooperative environment where teachers participate in numerous computer-supported cooperative work formations at the same time as they are expected to take part of vast amounts of organizational information. Most of these instances of cooperation are of a physical-virtual nature, where physical meetings are combined with virtual cooperation based on one or several concurrently used groupware.

The results show the limited existence of organizational guidance on how individuals and cooperative units should arrange their work following the deployment of the learning management system Fronter. This caused a situation were collaborating individuals had to find their own solution for how to arrange work and manage the extensive amount of interaction and information that characterized their work environment. Furthermore, all reported cooperative activities involved physical as well as virtual cooperation where some tasks are preferably managed in physical cooperation while others are usually managed in virtual cooperation. We further found how individuals deploy individual strategies for managing the layout of work, among which only focusing on information relating to certain groups, only monitoring cer-

tain information spaces, using fixed time slots for cooperation and information retrieval could be mentioned.

This final paper addresses how the multitasking layout of work in combination with extensive use of technology (originally expected to make our lives easier) often causes fragmentation, messiness, and contributes to the development of demanding work contexts. As a consequence this paper helps identify interesting future areas of research concerning integration of technological support for physical/virtual cooperative work.

Chapter 6

Conclusions and practical Implications

An ambition of this work is to explore how multitasking individuals manage to find a balance between task execution and articulation work in computer-supported cooperative work. One of the reasons for choosing this formulation was to be able to include and present functional strategies for finding a balance, even those that are not directly related to technology use, or that are not easily converted into design implications as such.

6.1 Conclusions

This section is structured based on the specific research questions formulated in the beginning of the thesis.

- How do cooperating and multitasking individuals manage availability in a physical/virtual work environment?

The main challenge associated with managing availability in physical/virtual work environment is: How to signal availability levels to others and how to estimate the availability levels of others without demanding too much effort from cooperators.

Multitasking cooperators active in a physical/virtual work environment manage availability by relying on explicitly and implicitly shared information - In the study of researchers at Luleå Technological University (paper 2 and 3) a continuous online media space session (the e-corridor) played an important role in how availability was managed among cooperators. Two of the functions provided in the media space were crucial for this purpose i.e. a public chat and a function for sharing broadcasted video from the offices of cooperators. Through the e-corridor, cooperators managed availability by reliance on explicit/implicit sharing of information. Several examples of sharing availability information through explicit techniques were observed, e.g. stating a reduced level of availability in the public chat, such as 'Lunch', or turning the camera towards the wall or turning it off. Availability management was also to a large extent managed implicitly through monitoring and drawing conclusions based on observed activities and appearances of others. Wearing a headset for example, indicated either participation in an e-meeting (if mouth movements were observed and the microphone was placed in position) or that a person was listening to music (if the microphone was not in position). Another example of implicit availability management was how being turned towards a visitor seat positioned outside of the camera view indicated that a visitor was present. Managing availability implicitly is beneficial for cooperators, as it demands less effort. This is due to how information about availability is shared as a by-product of other activities (i.e. demands no additional actions).

Multitasking cooperators active in a physical/virtual work environment manage availability by relying on synchronously and asynchronously shared information – As shown above, synchronously shared information is important for availability management in a physical/virtual work environment. Due to the fact that online media space was continuously running, estimations of availability were also based on asynchronous events such as previously added contributions in the public chat, previously observed behavior (e.g. through broad-

casted video), or previously observed appearance (e.g. wearing a suit indicates representation). Basing estimation of availability on various forms of information sharing is beneficial for multitasking cooperators as they can choose the situations in which they want to monitor the information sent from other colleagues. Contributions in the public chat were visible over time and the continuous sending of video provided good opportunities to develop an understanding of the whereabouts of others, even if not constantly monitored.

Norms and understanding of non-norm behavior is important for interpreting the availability information shared from others - Determining availability of others is always associated with interpretation efforts and when relying on implicitly shared information these interpretations become even more complex. Due to longitudinal coexistence and the rich flow of informal interaction, most cooperators commented on rather well established norms supporting such interpretations. These norms were not static, instead they had changed over time and several of the cooperators making use of the e-corridor described current and previously existing norms. One norm that had at the time of the study been abandoned consisted of attaching a post-it note in front of the web camera, for example with an away message saying something like 'downtown'. A current norm for signaling the same level of availability could be mentioning an errand in the public chat or just put the outdoor clothes on and leave (even if this behavior should be considered as somewhat ambiguous). In the same way as virtual coexistence enabled development of norms it also supported acceptance and understanding for non-norm behavior. Cooperators mentioned several instances of individual behavior that did not follow the established norms and these behaviors were not expressed as problematic, probably due to the rich flow of informal interaction circulating among cooperators in the e-corridor.

To sum up, multitasking cooperators manage availability in a physical/virtual work context through relying on implicit/explicit and synchronous/asynchronous sharing of information interpreted in relation to dynamic norms and understanding of non-norm behavior.

- How do groups of cooperating and multitasking individuals regulate the disruptive effects of interruptions without threatening their mutual interaction needs?

Based on how essential informal interaction is for managing cooperative work, the main challenge for cooperators in relation to this research question is: How can cooperators satisfy their need for informal interaction without causing disruptive effects for the work of other cooperators?

Cooperators regulate the disruptive levels of interruptions by taking their own work context as well as the individuals they want to establish interaction with into consideration – Besides the estimated availability of the targeted individual, cooperators do also take social and contextual factors into consideration before attempting to establish interaction. This claim is specifically addressed in one of the included papers (paper 4) but is also supported in others (i.e. 2 and 3). In paper 4 it is argued that if information about the social and physical context is available it is likely that aspects such as the location of the target for interaction, the relationship between cooperators, whether or not the target is involved in conversations or collaborations with others are taken into consideration. It is further argued that when responding to an attempt to establish interaction the same factors are presumably involved in the decision of if and how to respond. As mentioned above findings from the e-corridor study partly confirms the accuracy of these highlighted aspects.

Contextual and social factors influence the selection of channel through which interaction is established - In the e-corridor case (paper 2 and 3) it was found that cooperators were skilled at estimating if the context of another cooperator was in such a state that establishment of interaction would likely have disruptive effects. Respondents also stated that this was something that was taken into consideration when deciding through which communication channel to establish interaction. Asynchronous communication channels were preferred in situations when cooperators were estimated as busy, for example when talking on the phone and synchronous communication was avoided due to its disruptiveness. One example of a norm related to this issue was to send a private chat message with an invitation to es-

tablish interaction, often through short messages such as 'audio?' (i.e. can we interact through audio?) or 'ping' (i.e. is it okay to establish interaction?). The reason for using asynchronous channels in these situations was due to how it was experienced as less intrusive as it did not demand immediate attention. The small sized pop-up window containing the invitation was visible as a reminder until the targeted individual found the time to act on it.

Cooperators reduce the need for explicit interaction by relying on implicit forms of communication - In the e-corridor cooperators reduced their interaction needs by supporting publicly visible interaction through chat and broadcasted video. This interaction that was also possible to follow asynchronously reduced the level of interaction needed to develop an understanding about questions such as, what are cooperators working with? Where are they? Are they available for interaction? If chat and video had not been provided this type of information would have had to be gathered through other, probably explicit, means (or not gathered at all). A similar reliance on current and previous events was also observed in the hunting case (paper 1) and it is easy to imagine how explicit interaction such as verbal interaction could have had disruptive effects for hunters. Explicit interaction through gestures was seen, but demanded synchronization. Instead hunters monitored and remembered each other's movements and actions for acquiring the information they needed. In situations were no or little information about the current activities of other hunters were available, a hunter relied on previous observation related to direction of movements, speed, and position for deciding on how to proceed.

To sum up, cooperators strive for reducing the disruptive effects of interruptions by taking the work context of themselves as well as the individuals they want to interact with into consideration. Based on an understanding of the situation of others a suitable method for establishing interactions is selected. Cooperators benefit from reliance on implicit interaction as this reduces the total amount of explicit interaction that is needed.

- How do cooperating and multitasking individuals go about searching for each other for establishing interaction without caus-

ing extensive search time and substantial amounts of disruptions?

When taking the extensive interaction needs of cooperators and the disruptive effects of interruptions into consideration one of the key challenges related to finding a balance in cooperative work is to reduce interaction search time for cooperators and to avoid disruptive trial and error processes. This question was specifically addressed in paper 5 but was also touched on in paper 2, 3 and 4.

The availability of others is an important factor when searching for interaction - When a cooperator needs to establish interaction with other cooperators several factors, of which availability is one, are taken into consideration. In a situation where only one cooperator is available it is easy to imagine what the outcome will be, that is, if the available cooperator can satisfy the needs of the cooperator searching for interaction. In other situations the interaction search process is much more complicated.

Searching for interaction is typically associated with taking part in negotiations - Once a cooperator approaches another for establishing interaction a situation of negotiation takes its beginning. In this negotiation the work situation of the targeted individual as well as the interaction forager is taken into consideration. This is an aspect of interaction search behavior that is also highlighted in other papers included in this thesis (i.e. paper 2, 3, 4). In the e-corridor a kind of negotiation consisted of sending 'ping' or 'audio?' to another cooperator. This is a negotiation from which the result could be that no interaction is initiated (if there is no answer or if it is to late), that interaction is initiated through audio, or that interaction is initiated through some other communication channel. The result of such an instance of negotiation could benefit none, one, or both of the involved cooperators and it might even be the case that the initiator has to continue and approach another cooperator for interaction. In the logistic study it was found that the negotiations not only concerned whether or not or through which channel to interact, dispatchers and drivers also negotiated about whether or not they could provide the services needed. The result of negotiations contributes to development of a shared history that could guide behavior in future situations (e.g. if someone is

helping me now I ought to help that person some other time). This is related to the ripple effect of 'social relation' put forward in paper 4 as a social factor that is decisive for how an interruption is managed and whether or not it occurs in the first place. Negotiations do also support development of an understanding of a cooperators characteristic e.g. is it a helpful, competent or busy person.

Searching for interaction is a social process - In the logistic case it was also found that cooperators sometimes played an active role in another cooperator's search for interaction. Drivers could for example show their availability through entering a two-digit number on their radio. They sometimes also suggested suitable candidates for interaction. This behavior was also seen in the e-corridor study as cooperators continuously helped each other in finding people they were looking for, or to identify someone with a certain skill.

Maintaining the cooperative work formation is a factor that influence interaction search behavior - Due to how competence as well as productivity differs among cooperators it is in the cooperative work formation's best interest that the most capable actors are as active as possible. On the other hand it may become counter productive to overload these individuals while not utilizing others. In the logistic case (paper 5) some drivers were experienced as more valuable than others, an estimation based on their social abilities such as problem-solving skills, attitudes in social negotiation, routines for making themselves reachable, for signaling availability etc. Drivers that were considered as less valuable by dispatchers were also assigned jobs, but these jobs were often of a more simple nature. Even if it would be difficult to argue that cooperators active in the e-corridor followed a specific strategy for maintaining the cooperative work formation, the workloads of others were considered before making a decision of with whom to establish interaction.

To sum up, interaction search behavior is a complex process in which the availability of others, the result of current and previous negotiations, and network maintenance are considered. Interaction search behavior is also a social process in which cooperators, if they can, help each other in satisfying interaction needs.

- How do cooperating and multitasking individuals manage extensive levels of information and interaction associated with work articulation of multiple cooperative activities?

As described in the introduction, one of the characteristics of modern work is that cooperators are commonly involved in several cooperative work formations running in parallel. This is indeed a challenge for cooperators as they need to find a balance between individual task execution and work articulation in relation to not only one, but several instances of cooperative work. This question was specifically addressed in paper 6, but touched on in several other papers.

Norms are important for managing participation in multiple cooperative activities – Teachers at the senior high school took active part in numerous cooperative work formations often making use of different sets of applications, or using similar applications but in different ways. The amount of information and interaction that circulated through these applications or in the physical workplace was by all teachers experienced as insurmountable. One of the most striking observations was how teachers suffered from the absence of norms for interaction and information sharing at the school. Norms are important for cooperative work formations as they suggest how to behave, and how not to, in different situations. Some vague norms were explicitly stated as Fronter was implemented, these norms were however not related to teacher-teacher cooperation and as a result a 'communication crisis' took its beginning as soon as the system had been implemented. Over time various cooperative work formation developed their own strategies, due to how these were not easily shared among teachers there was a great difference in which norms that were applied and there was little room for learning from each others' mistakes and progress. The importance of norms is discussed in relation to other research questions, as well as how vital informal communication is for development and maintenance of these. In the senior high school one of the first decisions when introducing Fronter was to close down the most vital channel for informal communication, the FirstClass conference 'staff info'. This was not a wise decision.

Multitasking cooperators manage the extensive amount of interaction and information associated with cooperative work through

applying various filtering strategies – For managing the vast amounts of interaction and information related to participation in multiple cooperative work formation all teachers had deployed strategies for filtering out information and interaction that they did not consider as important. These strategies were very different in nature and consisted of: only taking part of information directly related to colleagues or students, only taking part of interaction through certain communication channels, only taking part of information posted on certain places, only taking part of information and interaction during certain time slots and a somewhat extreme filtering technique applied by one respondent of letting other cooperators filter information for him. These techniques that were often applied in combination were associated with making use of quite diverse applications and were all based on the basic idea of only taking part of information that has a direct or an indirect impact on the cooperator's work.

To sum up, norms are important for supporting cooperators in managing participation in multiple cooperative work formations. In the absence of well-established norms for managing vast amounts of interaction and information, individuals find their own strategies for filtering out information they consider as less relevant. The lack of suitable channels for informal interaction inhibits sharing of these norms and strategies.

6.2 Summarized conclusions

Striking a balance in cooperative work is a process that includes a wide range of different balancing acts. It includes finding a balance between being available for interaction and being able to focus on individual work, it includes enabling informal interaction without causing extensive amounts and disruptive effects of interruptions, it includes enabling interaction search behavior without causing extensive search time and disruptive effects, and it includes finding a balance between various instances of cooperative work. Even though very different cooperative work formations face a similar set of challenges related to striking a balance in work, various aspects such as work structures, task types, available technologies and contextual constrains govern which challenges that are experienced as most demanding. In the process of computer-supported cooperation, work formations adapt to

the circumstances under which they are working by designing their own work situations. As such, finding a balance in cooperative work is only to some extent an individual concern. Cooperators, if they can, help each other to find a balance in cooperative work by for example taking the work context of each other into consideration before establishing interaction (paper 2 and 4), or by helping each other to find individuals for interaction (paper 5).

Norms are a key construct for striking a balance in cooperative work. These, like all interaction mechanisms, are beneficial for reducing the amounts of interaction needed for work articulation and have in this exploration been shown to be extremely valuable. Development and maintenance of norms does however demand interaction, preferably informal interaction. The thesis has shown the consequences of not promoting informal communication to a sufficient degree (paper 6). Teachers at the senior high school experienced a 'communication crisis' at least partly due to the absence of norms, forcing them to establish individual strategies for coping with their work situations. The thesis has also been able to show how technology can promote individual interaction among cooperators, even when these are distributed (paper 2 and 3). Norms also play an important part in estimating the availability of other cooperators. As individual task execution is an important part of cooperative work and as cooperators are involved in collaborative multitasking, there are periods during which they are less available for interaction. Availability management in a physical/virtual work environment can be managed by reliance on implicit as well as explicit information sharing (paper 2). Through the longitudinal use of an asynchronous media (i.e. a public chat) and synchronous media (i.e. broadcasted video) cooperators in the e-corridor developed and maintained norms for making estimations of each others' availability. Availability was only one of the factors that were found as influential for interaction search behavior in a cooperative work formation (paper 5). Other factors with an influence were results of previous encounters, experienced competence of cooperators and network maintenance. This further highlights the influence of social factors on cooperators behavior and their ability to find a balance in work.

Based on the exploration of various cooperative work formations' strategies, challenges and use of technology for striking a balance in

cooperative work several conclusions have been reached. Some of these conclusions are directly related to specific research questions while others are more general and related to the overall research question. The overall conclusions of this thesis can be formulated as follows:

- Multitasking cooperators are constantly struggling to find a balance between focusing on articulation of work and individual task execution, commonly in relation to several cooperative work activities.

- Strategies for finding a balance in cooperative work are developed in relation to the context in which the activity takes place. Cooperative work formations over time 'design' their use of technology, structures, procedures and norms etc.

- Multitasking cooperators active in a physical/virtual work environment manage availability by relying on explicitly/implicitly and synchronously/asynchronously shared information. For interpreting information related to the availability of other cooperators norms and understanding of non-norm behavior is of key importance.

- Cooperators regulate the disruptive levels of interruptions by taking the work context of themselves as well as the individuals they want to establish interaction with into consideration. If several communication channels are available, the work context of others influence the selection of channel through which interaction is established.

- Interaction search is a process characterized by negotiations and is influenced by the availability of cooperators, results of previous encounters, estimated competence of cooperators, cooperators willingness to assist as well as network maintenance efforts.

- Norms are important for finding a balance in computer-supported cooperative work due to how they reduce the interaction needed for work articulation. In the absence of established

norms, cooperators manage extensive amount of interaction and information through applying various filtering strategies.

Based on these conclusions a set of practical implications for practitioners struggling to find a balance in work and for designers of supportive technology can be identified.

6.3 Practical implications

The implications presented in this section should not be taken as direct requirements for design or for practitioners i.e. individuals active in modern organizations struggling to find a balance in work. Further research is needed before reaching such a detailed level of guidance.

6.3.1 Implications for designers of supportive IT

Supporting smooth and effortless task switching - Due to the frequent switches between various instances of computer-supported cooperative work and between individual task execution and work articulation within these it is of focal importance to support task switching. For designers of supportive technology this suggests that interoperability of systems is of key importance. As task switching often involves making switches in IT use as well, supportive technologies should reduce the time it takes to go from one work context to another, but also to reduce the time that it takes to get back to a previously abandoned work task.

Sharing of contextual and social information among cooperators - Due to how cooperators take the social and physical context of others into consideration it is important to mediate this kind of information to others. This has the potential of reducing the frequency and the disruptive effects of interruptions. For designers of supportive IT this proposes deployment of communication channels for lightweight informal interaction as well as various forms of awareness systems. As the physical location of a cooperator seems to be important, location aware technology ought to be considered. Technology for supporting sharing of this kind of information has the potential of not only reducing disruptive effects of interruptions but also to increase the likelihood of succeeding in establishing interaction.

Encourage usage of various forms of interaction channels – As this investigation has shown, initiators of interaction select communication channels that are considered as appropriate in relation to the work situation of the targeted cooperator, usage of a wide range of communication forms should be encouraged. For designers of technological support, this implication suggests providing cooperators with several communication channels. This includes synchronous, asynchronous, explicit, implicit, heavyweight as well as lightweight alternatives that all have a purpose to fill in computer-supported cooperative work. Due to the interdependency in cooperation it could be very disruptive not to be able to establish interaction or if an interruption occurs in an inappropriate situation. If awareness information is shared to such an extent that cooperators can estimate the appropriateness of establishing interaction, they can choose a channel that corresponds to the availability level (including social and contextual factors) of the recipient. These channels should also be easily integrated so that interaction via one channel can easily be converted to another.

Enable flexibility in cooperation – As a cooperative work formation designs their work activity in relation to the context in which it takes place, different formations have different requirements when it comes to technology, procedures and norms. For designers this characteristic of cooperative work is associated with a need to design IT-support for flexibility. To view a system as an arena that is providing a wide range of functionality could be a suitable approach, as the IT in itself does not force a specific way of doing work. Instead cooperators should be provided with the opportunity to calibrate their IT-use based on individual and cooperative requirements. This design approach makes it more likely that several cooperative work formations with quite different demands can use the same system. A danger with this approach is that it might be difficult to ensure that all needed functionalities are available in the system. As a consequence, this approach needs to be complemented with openness to adding other types of functionality to the main system.

Encourage establishment and negotiation of norms - As shown in relation to several of the conclusions, norms are important for cooperation due to how they support articulation work throughout the cooperative work process. As norms can guide cooperators in under-

standing what is and what isn't acceptable behavior they are of key importance for striking almost any type of balance in cooperative work. For designers of supportive technology the most obvious suggestion is to include channels for informal communication in the systems they design. Previous attempts to promote informal communication among distributed cooperators have to a large degree been unsuccessful but, as shown in this thesis (paper 2 and 3), reliance on constantly visible, public, and asynchronous communication channels has great potential. Relying on channels with these characteristics for informal interaction is beneficial as it does not radically increase the amount of disruptions for individuals and does not exclude participation from more peripheral cooperators.

Support filtering of awareness information - Due to the vast amounts of information sharing and interaction needed for articulation work, and the fact that multitasking individuals at times need to be able to work without being disrupted, it is important that cooperators can filter the information that they share with, and receive from, other cooperators. For designers of supportive technology this suggests that efforts should be directed to providing cooperators with functionality to apply various forms of filters. One way could be to implement an intermediary system where information and interaction labeled in a certain way is delivered in accordance with socially and individually created profiles. These profiles should contain information about what kind of information to receive, how to receive it and from whom. These settings should be easily recalibrated as the dynamics of modern work can easily make previous settings obsolete.

6.3.2 Implications for cooperators

The main contribution of this thesis for cooperators struggling to strike a balance in their work is the detailed description of four different cases in which cooperators' and cooperative work formations' balancing efforts are outlined. By considering these efforts, and by relating them to their own work situations, cooperators can find some suggestions about how to strike a balance in their specific work situation. Unreflective adoption of other cooperators' strategies is however hazardous as formations and individuals develop their own strategies for

striking a balance in relation to their specific work context. However, there is room for providing some general implications that should be considered by cooperators active in modern organizations.

Encourage sharing of awareness information – This thesis has accentuated the importance of sharing information among cooperators for the development of awareness. When a cooperator shares information about his or her work context with others, they can take this information into consideration when for example deciding if interaction can be established, how to establish interaction and how to respond to an attempt by the cooperator to establish interaction. The thesis has shown that others take the social and contextual situation of a cooperator into consideration in various ways. How to mediate such information to others is very much dependent on the specific context of a cooperator. One general suggestion is to engage in rich and frequent interaction, if possible through asynchronous, publicly available and ongoing channels.

Encourage use of a wide set of communication channels – One situation in which the work contexts of others are taken into consideration is when choosing how to establish interaction. For this reason it is important that a wide set of channels are available and used in computer-supported cooperative work formations. Due to the social nature of work in modern organizations, which communication channels to use is not a decision made by a single cooperator. A cooperator can encourage use of a wide set of channels by being aware of the available alternatives and put forward these in discussions related to which work forms to apply and which IT to use.

Encourage and engage in informal interaction – The thesis highlights the importance of norms for striking a balance in computer-supported cooperative work and as these are developed through rich and frequent interaction a suggestion to cooperators is to see to it that this kind of interaction can flourish. Informal interaction is also beneficial for other reasons, such as for development of awareness, for finding structures and procedures that are beneficial for finding a balance in work, etc. Providing guidance about how to encourage informal interaction is difficult as it is dependent on the specific work contexts of cooperative work formations. For one formation this could be

managed through use of a public chat or an IM system, for another formation it could be sufficient to share a coffee room.

Set up rules for management of your work – As cooperators are working in contexts that are, to a large extent, created by others the possibilities to apply individual strategies for striking a balance are limited. However, as shown in the senior high school case, it might be necessary to do so in some situations. From one point of view this could constrain possibilities for cooperative formations to be efficient and to articulate work smoothly, but from another point cooperators in the e-corridor were quite forgiving when it came to accepting individually developed and applied strategies. Cooperators are different and it is important for each and every one to reflect on what works for them and to communicate these preferences to others in an unobtrusive way.

Chapter 7
Discussion

The purpose of this thesis was to explore how multitasking individuals manage to find a balance between task execution and articulation work in computer-supported cooperative work, what challenges they face in the process, and how IT should be designed to support them. In order to reach this purpose a main research question was initially stated, broken down into a number of questions explored in the included papers. Based on the outcome of this exploration, a set of conclusions have been presented as well as some implications of these for cooperators and designers of supportive IT. The intention with this discussion is to place the conclusions of the thesis into context, discuss them in relation to the practical implications, discuss implications for further research on striking a balance in cooperative work, discuss limitations of this work, and to point towards directions for future research and design of technology related to the topic of this thesis. Before going into the discussion, some clarifications regarding the generalizability of the conclusions seem appropriate. This is especially important due to the often-expressed concern with reference to case

studies, that they constitute a weak foundation for making generalizations. Yin (1994) meets this claim by saying:

> [...] case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment, does not represent a "sample," and the investigator's goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization). (Yin, 1994, p. 10)

As such, analytic generalizations can be made based on case studies by using a previously developed theory as a template with which the empirical data is compared. If several case studies support the same theory the researcher can claim to have found replication and tendencies, not predictions. Walsham (1995) takes this even further by outlining four types of generalizations that can be made based on interpretative case studies: development of concepts, generation of theory, drawing of specific implications, and contribution of rich insight. This work strives for analytic generalizability when it comes to what Walsham (1995) terms rich insight by presenting and outlining the complexity of several instances of computer-supported cooperative work. Another ambition is to contribute to the development of theoretical concepts related to computer-supported cooperative work, this with a firm belief that an extended understanding of these concepts can support other CSCW researchers in grasping the complexity of cooperative work. No claims are made for statistical generalizations. With that said it is now time to move over to the discussion.

7.1 A constant struggle for finding a balance

The first conclusion highlighted the constant struggle of cooperators for finding a balance in work, commonly in relation to several instances of cooperative work. Previous research on work in modern organizations has emphasized its fragmented (e.g. Speier et al. 2003, Czerwinski et al. 2004, Iqbal and Horvitz, 2007) and multitasking nature (e.g. Leroy and Sproull 2004, Gonzalez and Mark 2004). As computer-supported cooperative work is associated with execution of individual work as well as overhead work (Carstensen 1996, Mintzberg 1999, Schmidt 2006), primarily managed through rich and frequent, often computer-mediated interaction (Galbraith 1977, Katz and Tushman 1978, Schmidt and Bannon 1992), cooperators and the work for-

mations to which they belong face the challenge of trying to strike a balance in work.

The present exploration has accentuated the notion of the modern workplace as a context characterized by work fragmentation, multitasking and task switching. It has further been shown how finding a balance in cooperative work involves a set of different but tightly integrated balancing acts. For example, cooperators need to find a balance between being able to focus on individual work and taking part of informal interaction for articulating work, between satisfying their interaction needs and reducing disruptive effects of interruptions, between searching for interaction and interrupting others, etc. Even if these balancing acts are integrated, a wide range of factors determines which are more central and which are more peripheral for a certain cooperative work formation. All work formations explored in this thesis do however share the same struggle for finding a balance between individual work and work articulation.

Hunters (paper 1), researchers (paper 2 and 3) and teachers (paper 6) were found to make continuous switches between focusing on individual work and engaging in work articulation. While hunters and researchers considered these frequent switches in focus rather unproblematic, teachers found them much more demanding. This was primarily due to how their shifts were associated with making use of different technologies, but also because of the poor guidance in norms for technology use. While the process through which cooperators make switches between focusing on different aspects of work has been explored in previous research (e.g. González and Mark 2004, Czerwinski et al. 2004) the main focus has primarily been on management of individual tasks. With some notable exceptions (e.g. Gonzalez and Mark 2005, Plaisant et al. 2007, Tolmie et al. 2008) few efforts have been assigned to exploring the consequences of making switches between various instances of cooperative work. This is an aspect of modern work that is specifically addressed in one of the included papers (paper 6), which calls for a redefinition or at least a broadening of the theoretical concept of multitasking. A consequence of collaborative multitasking at the senior high school was that teachers were unable to take part in work articulation of all the cooperative formations to which they belonged. As an attempt to solve this, products of articulation

work (e.g. minutes) were made available in a shared workspace, which should be seen as a compromise between being able to articulate work at all and to involve all cooperators in the process. This solution probably influenced the quality of the overall outcome in a negative way. In addition, even if products of articulation work were available for teachers, they experienced problems related to finding them and to find the time needed to take part of them in retrospect.

As finding a balance in cooperative work is managed by making frequent switches in focus and between tasks, it becomes of central importance for designers of supportive IT to reduce the cost in time and effort of making these switches. Designers should also consider the fact that cooperators make these switches not only between individual tasks but also between various instances of cooperative work activities. Since task switching is often associated with making switches in IT use, it could seem a good idea for an organization to implement a system that offers all imaginable functionality to its users. In an ideal situation, this could avoid time wasting processes of switching between repertoires of technology. This was actually the rationale behind the implementation of Fronter at the senior high school (see paper 6) but, as it turned out, Fronter became just another system to manage as it failed to provide all the functionality needed by teachers.

An alternative approach could be to promote manipulation of products of a wide range of applications as single units. This is the rationale behind the UMEA system (Kaptelinin 2003) and the Scalable Fabric system (Robertson et al. 2004). As a consequence, these systems both support task switching and recuperation of previously abandoned tasks, while the so-called reminder systems (e.g. Renaud 2000, Czerwinski and Horvitz 2002) only support task switching. A shortcoming of all these designs for supporting task switching is that they do not take cooperative multitasking into consideration. Switching between tasks related to different cooperative work formations is more complex as, while focusing on tasks related to one cooperative activity, articulation work in relation to another might have changed the conditions for individual task execution (e.g. how, when, and if the task is to be executed). This suggests that, for example, the reminder functionality in the UMEA system ought to be complemented with a

notification feature that conveys the changes made by other cooperators when switching work contexts. Further development of the system in that direction would be an interesting step forward.

7.2 The adaptability of cooperative work formations

The second conclusion highlighted the adaptability of cooperative work formations and how they over time 'design' their work processes in relation to the context of the activity. This highlights the adaptability of cooperators and how 'designed' work processes are compromises between factors such as needs, resources and constrains, but it also fits well with the observation of Orlikowski and Scott (2008) that technology is inseparable from the social and should be viewed and studied as such.

Hunters (paper 1) could not rely on IT for taking on the cooperative activity and instead relied on norms, structures and predominately non-verbal, often implicit, interaction. Even though norms, procedures and structures were also important in the other cases, technology plays a much more prominent role in these. The importance of IT for modern work organizations should not be underestimated, especially when cooperators are distributed, but aspects such as structures, procedures and norms can compensate for weaknesses in technological support, reduce unwanted effects and sometimes even replace the technology (as was the case for the hunters).

An example of how norms complemented IT use was seen among researchers making use of an online media space for cooperation. These relied to a large extent on norms for interpreting the information received from others for estimating availability. The structuring of teachers at the senior high school into work related groups could be seen as a way to reduce the effects of extensive computer-mediated information sharing and interaction. Even though these examples illustrate the adaptability of cooperative work formation, it is worth mentioning that these compensations sometimes come at a cost of reduced efficiency or delimited capabilities. Based on this notion of how cooperative work formations design their own work processes, not only technological solutions should be considered for managing the challenges related to finding a balance in computer-supported cooperative work. It might as well be the case that different structures

or procedures should be applied, or that the IT needed for addressing a specific challenge is IT for encouraging the development of norms.

As cooperators often make use of a wide range of technologies for designing their work processes the coordination of these should be supported. This speaks in favor of customizable systems providing a wide range of functionality from which formations can choose which ones to make use of and how to use them. This suggestion is in line with one of the ideas behind of the UMEA system (Kaptelinin 2003) and the Scalable Fabric system (Robertson et al. 2004), which is to abandon the application-centric view of design. Kaptelinin and Boardman (2007) take one step further as they argue for adaptation of a new perspective in the design of supportive IT, a perspective concerned with improving support for individuals across their workspace as a whole, complementing the currently dominating application-centric perspective. Even though Kaptelinin and Boardman mainly propose this perspective for email research, the value of it for design of other types of IT should be considered. The work presented in this thesis speaks in favor of such an exploration.

7.3 Managing availability through reliance on various forms of information

The third conclusion stated that cooperative work formations manage availability through reliance on various forms of information sharing. Previous research on availability management in co-located work settings has shown the importance of implicit forms of interaction for signaling availability levels among cooperators (e.g. Knapp 1978, Argyle 1988). For cooperators working across distance through the use of technology, this is an aspect of availability management that is poorly explored in research and poorly supported by IT. Most technology for supporting availability management across distance relies on explicit approaches (e.g. Wiberg 2002, Begole et al. 2004), with some notable exceptions (Hudson et al. 2003, Begole et al. 2004, Fogarty et al. 2004a, 2004b, 2005). Relying on explicit strategies is problematic due to how this demands effort from already overburdened cooperators.

It has been shown in this thesis how distributed cooperators can rely on implicitly shared and computer-mediated information for availability management. This adds to the current body of research

related to availability management in CSCW. It also adds to previous research related to informal communication by showing how informal interaction can flourish even in distributed work settings. Previous research on this issue has emphasized the importance of collocation for achieving substantial levels of informal interaction (e.g. Kraut et al. 1990a, Whittaker et al. 1994, Jeffrey and McGrath 2000, Kiesler and Cummings 2002). In comparison to relying on explicitly shared information for signaling or estimating availability levels of others, reliance on implicit sharing of information is beneficial for finding a balance in cooperative work as it does not demand explicit communication acts, at least not from one of the involved parts. The value of implicit forms of communication has been emphasized elsewhere in the terms of feedthrough (Ljungberg 1999), or Stigmergy (Christensen 2008 drawing on Grassé 1959). This thesis contributes to this work by showing how cooperators in the e-corridor (paper 2 and 3) relied on a combination of implicitly and explicitly shared information for managing availability, where implicit information was predominately conveyed through informal interaction in a public chat and via broadcasted video.

It has also been shown how beneficial it is for cooperative work formations to rely on asynchronous communication channels for informal and implicit information sharing, as this information can be taken part of in retrospect. This is especially beneficial in the case of collaborative multitasking, as synchronous channels demand immediate attention. Malone and Crowston (1990) argue that the best coordination processes are those that are difficult to observe, i.e. those that unfold in the background without demanding explicit acts from the involved individuals. Even if some instances of direct coordination were seen in the chat, the main benefit of the channel was how it promoted development of a foundation on which coordination could take place at a later stage. Another important channel for implicit sharing of information was broadcasted video. To interpret the implicitly shared information through these channels, cooperators relied on norms developed from a lengthy and continuous flow of informal interaction in the e-corridor. This prolonged coexistence of cooperators in fact also supported the acceptance of non-norm behavior.

Based on the value of public chat and broadcast video for distributed cooperators in the e-corridor, designers of supportive IT should consider providing similar functionality for distributed cooperators in the systems they design. But there are some concerns that need to be reflected upon. First, the main reason for the successful use of either one of the functionalities in mPro was due to how well complemented they were by the others. Public chat was essential for the development of norms, which were essential for processing implicitly shared information, which was in turn essential for interpreting the availability of others. As such, there exists interdependency between the different functionalities. Second, the online media space, especially with the use of video and audio, is a rather heavyweight system demanding initial calibration efforts and continuous use of computer power. This might be experienced as too cumbersome to manage, especially for a peripheral cooperator. Third, even though cooperators in the e-corridor did not consider integrity to be an issue it is however likely that other formations would.

If these concerns are considered there is great potential in the functionality provided in the studied online media space, especially in having an ongoing public chat for promoting informal communication, development of norms and implicit management of availability.

7.4 Reducing disruptions by considering work contexts

The fourth conclusion highlighted the social nature of cooperative work and how cooperators, if they can, take the work contexts of others into consideration in various situations, for example when establishing interaction. It was established early in the area of CSCW that individuals help each other in cooperation by for example supporting development of awareness (e.g. Heath and Luff 1992, Benford and Fahlén 1993, Rodden 1996). In the process of writing this thesis several other ways through which cooperators help each other have been found. As a consequence, it can be seen that finding a balance between articulation work and individual task execution is not solely an individual concern. Heath and Luff (1992) showed how co-located cooperators, when talking on the phone, raised their voice regarding certain issues so that others would hear. In this thesis, several instances of similar behavior have been found, and one of the included papers

(paper 4) is completely devoted to showing how cooperators consider social and contextual factors when establishing and when responding to attempts to establish interaction. The paper expands the notion of interruption management to also include social and contextual aspects such as interpersonal relation (a factor that is according to Davis and Gutwin (2005) also influential for an individual's availability for availability), location (of the interruptee) and (whether or not an individual is involved in) communication or collaboration. Even though further exploration is needed in order to explore to what extent these factors influence interruption management, other cases included in the thesis provide some findings pointing in this direction (e.g. paper 2).

Cooperators in the e-corridor made decisions about how to approach other cooperators based on what they knew about their work situation and relied on a specific routine of negotiation and less intrusive communication channels when approaching a colleague interpreted as being less available. This is inline with the suggestion of Fussel et al. (1998) to make use of asynchronous channels to reduce the risk of creating overload, even if their suggestion was to exchange face-to-face communication with communication via email. Even if some research exists related to channel selection in cooperation, more research is needed regarding this issue. As cooperators take social and contextual factors of others into consideration, finding a balance between articulation work and individual task execution is not only an individual concern. Preparations for an experimental study of the influence of social and contextual factors for interruption management are currently being made.

Based on how social and contextual factors are taken into consideration in computer-supported cooperative work, designers of supportive IT should promote development of awareness regarding these factors among cooperators. Cooperators should also be provided with possibilities to act in accordance to this information, for example by selecting channels through which interaction is initiated. Systems supporting a wide range of communication channels, in combination with tools for mediating awareness of the social work context of others, would not only have the potential to reduce the disruptive effect of interruptions but would also increase the overall percentage of successful establishments of interaction. Suitable approaches for sharing

awareness information through informal interaction have been mentioned above. In fact, some of the early prototype systems for promoting informal communication presented in an earlier chapter had some effect on development of a shared culture and feelings of shared context (e.g. Fish et al. 1993). These systems did however have other drawbacks and more lightweight approaches are most likely preferable. There exist some systems for sharing awareness information through implicit means e.g. the Lilsys system (Begole et al. 2004), or MyVine (Fogarty et al. 2004b). The problem with these systems is that they delimit the information about cooperators that is shared, in the Lilsys system information about the work context of a cooperator was mediated through a three-grade scale indicating whether or not he or she is available, not available, or neutral. As such the system only supports the inclusion of some social and contextual factors and only to a limited extent. Further research is needed to explore how information about the work contexts of others is best shared in computer-supported cooperation.

7.5 The complexity of interaction search behavior

The fifth conclusion highlighted the complexity of interaction search behavior in social networks. Previous research of interaction in cooperation has primarily been directed towards formal and informal workplace interaction (e.g. Borning et al. 1991, Whittaker et al. 1994, 1997, 2002, Oehlmann et al. 1997, Lim et al. 2007) and little attention has been given to how cooperators search for interaction and the logic behind this behavior.

From a naïve point of view it is easy to assume that interaction search behavior is solely a trial and error process in which cooperators with interaction needs browse their network until these can be satisfied. If applied, this behavior would cause ample amounts of unnecessary disruptions as cooperators unable to help are approached in the process. This could be one the reasons behind the high levels of interruptions that characterizes the modern workplace. An improved understanding of interaction search behavior for informing design of supportive technology could be extremely valuable. The logistic case (paper 6) contributes to this by showing how a wide range of social factors governs interaction search behavior. Besides applying the the-

ory of information foraging (Pirolli and Card 1995, 1999) in a new domain (i.e. interaction search behavior), this exploration breaks new ground by showing how interaction search behavior is best described as a process of negotiation influenced by results of previous encounters, experienced competence of cooperators, network maintenance efforts, and assistance from other cooperators. Previous research on expertise location has addressed the issue of how to access experts in organizations (McDonald et al. 2000, Zhang et al. 2005) but, as the exploration at Bilfrakt.se shows, competence is only one factor that influences the search activity. Even if the other papers in this thesis did not focus specifically on interaction search, it was, for example, possible to see how searching for interaction in the e-corridor consisted of series of negotiations (paper 2 and 3), and how cooperators assisted each other in the process.

Designing supportive technology for facilitating interaction search behavior is a demanding task due to the range of factors that influence the process. First of all, this support needs to provide availability information about cooperators, as this is an influential aspect for whom to establish interaction with. Second, as negotiation is such an important part of interaction search behavior, systems designed to support these processes should support multiple, integrated, and open channels that allow lightweight and effective negotiations between cooperators. This includes supporting cooperators in finding the right person to contact but also supporting awareness of the channels through which cooperators are available. This complements 'peer awareness' systems, such as characteristic buddy lists that show who is online in the network and their status of availability. Third, as network maintenance is an important factor for whom to approach for establishing interaction, support for interaction search behavior should also provide information about the workloads of others. This is beneficial in order to distribute the interaction load over the network, with the objective of not overburdening some cooperators while excluding others. This is yet another factor that speaks in favor of providing cooperators with unobtrusive channels for informal interaction due to their strength in mediating such information.

7.6 Reliance on norms for finding balance in work

The final conclusion highlighted the importance of norms for computer-supported cooperative work formations. This has been emphasized throughout the thesis as a way to reduce the extensive amounts of interaction and information sharing needed for work articulation. This is in line with previous research that highlights the value of norms and other interaction mechanisms for this purpose (e.g. Schmidt and Bannon 1992, Luo and Olson 2006).

In the studied cases it has been shown how norms can reduce the amount of interaction needed in computer-supported cooperation in several ways, but also how the absence of norms can influence cooperative work in a negative way. For researchers active in the e-corridor (paper 2 and 3), norms served as an important tool for converting information sent from other cooperators into estimations of availability. Among teachers at the senior high school (paper 6), few norms existed about where to publish and access information and how to interact. As a result teachers missed out on information and interaction as they did not know where to look for it. This had two consequences for teachers that were both disruptive for cooperative work. Cooperators either missed out on information or interaction, or they had to ask someone where to find it (and by doing so increasing the total amount of interaction needed for articulating work). One of the likely reasons behind the limited existence of norms for interaction and information publishing/retrieval in the senior high school was the low level of informal interaction among teachers. Development and maintenance of interaction mechanisms, such as norms, demands interaction (Gerson and Star 1986, cited in Schmidt and Bannon 1992), especially informal interaction (Luo and Olson 2006) and one of the most important channels for this kind of interaction at the senior high school was shut down as soon as Fronter was introduced. In the absence of established norms teachers developed their own strategies for coping with the situation, but due to the lack of norms related to how and where to display information or through which channel to interact, teachers often missed out on information.

As norms are so important for finding a balance in computer-supported cooperative work, designs of supportive IT should provide functionality for promoting informal interaction. This has for a long

time been considered as difficult to achieve for distributed cooperators (Kraut et al. 1990, Whittaker et al. 1994, Jeffrey and McGrath 2000, Kiesler and Cummings 2002). This thesis has shown an example of how a formation of distributed cooperators managed to reach significant levels of informal interaction through use of an online media space and the functionalities it provided (paper 2 and 3). The main reasons for the success of the online media space were how it promoted informal communication through a channel that was continuously running and that the channel was asynchronous so that interactions could be taken part in later, presumably during less hectic periods. These characteristics of the channel made it appropriate for informal interactions among the multitasking cooperators. Another technology that has been considered as appropriate for promoting informal interaction is various instant messaging applications (Nardi et al. 2000, Herbsleb et al. 2002, Isaacs et al. 2002). Due to how IM primarily supports synchronous interaction between a limited set of cooperators such a system could complement, not replace, a channel such as public chat in a good way, much like the private chat in the mPro system complemented the public chat.

Awareness filtering technology (e.g. Pollock 1988, Lutz et al. 1990, Davis and Gutwin 2005) could be an alternative, or a complement, to norms for reducing the amounts of information and interaction that reaches a cooperator. The logic behind these systems is to filter out less relevant information or interaction. As what is considered as relevant is likely to differ quite radically from one cooperative work formation to another, and from one cooperator to another, general approaches for filtering of information and interaction should be dismissed (spam-filters excluded). It is inevitably so that some cooperators are more involved than others in a cooperative work formation and, as various degrees of involvement exist, it seems reasonable to promote filtering on the level of cooperators or formations. One thing that complicates filtering efforts is that awareness is developed based on information and interaction received through a diverse set of channels, so that filtering of unwanted information or interaction is indeed a complex challenge. One approach is to apply filtering functionality for each and every channel, e.g. filtering email based on content (Pollock 1988, Lutz et al. 1990). Even if there are approaches in which

collaborators help each other in maintaining these filters (e.g. Goldberg et al. 1992), this application-centered strategy (Kaptelinin and Boardman 2007) would however likely result in considerable amounts of overhead efforts from individuals.

Availability management systems are an alternative to these application centric approaches that could at least to some extent reduce loads on cooperators. This approach could rely on systems that automatically calculate and communicate availability levels of cooperators such as the systems put forward by Begole et al. (2004) and Fogarty et al. (2004b), or systems that regulates interaction and information sharing on a social level (e.g. the public chat and broadcasted video in the e-corridor). If the aim is to provide some directions for further designs of filtering technologies, there is a need to apply the workspace-level design perspective of Kaptelinin and Boardman (2007) in order to reduce the overhead efforts for cooperators. A notification system based on manually entered individual and socially negotiated preferences (related to form as well as content), in combination with context-aware technology, could mediate information and interaction to the individual cooperator at appropriate moments and in an unobtrusive way. Here the early attempt of Lövstrand (1991) should be acknowledged as a source of inspiration. It goes without saying that further research is needed before such a system could see the light of day.

7.7 Further challenges for designers of supportive technology

In the process of developing computer support for cooperative work formations and their efforts to find a balance between work articulation and individual task execution some important general challenges are faced.

The first challenge is related to the complexity of designing for one aspect of collaborative multitasking without causing negative side effects at another level. Various technologies have been developed that might support multitasking individuals in finding a balance between articulation work and individual task execution (see section 2.4). When considering all these technologies, and when taking the set of challenges that cooperators face into consideration, the conclusion of Markopoulos et al. (2005) that few systems are put forward that rem-

edy one challenge without worsening another seems to be valid for most systems. One example is the Interaction Manager system put forward by Ljungberg (1999). This system was developed for managing availability but also causes an increased level of interruptions. Or the approach by Lamming et al. (1994) to use a video log as a memory prosthesis for helping cooperators to find their way back to a previously abandoned task, which demands time and efforts from them to browse this log. Taking a more general grasp on the challenges that multitasking cooperators are facing for preventing negative side effects is an important challenge for the designer. Here this thesis plays an important part.

The second challenge is related to integrity (privacy) issues. This issue is often raised in relation to design of various forms of CSCW systems, such as systems for supporting availability management (e.g. Begole et al. 2004, Fogarty et al. 2004b), awareness (e.g. Godefroid et al. 2000, Davis and Gutwin 2005), and informal communication (Fish et al. 1993, Nardi et al. 2000). Integrity is an important aspect to consider in the design of CSCW systems and it becomes even more important given the increased reliance on implicit forms of communication for managing several of the challenges recommended in this thesis. When taking the integrity issue into consideration the previously presented implication for design of providing cooperators and cooperative formations with customizable systems seems like a suitable way forward. As was the case in the e-corridor and their use of the mPro system cooperators could choose whether or not they wanted to share video with others, whether or not they wanted to participate in the continuous flow of informal communication (taking place in the public chat), etc. This was a choice that several of the respondents had taken, for example by not sharing video when working from home. The consequence of adopting this type of behavior is of course that it becomes more difficult to rely on implicit forms of communication. However, an emphasis on the individual's possibilities for customizing their own technology use, by among other things taking integrity issues into consideration will be a winner in the long run.

Concluding remarks

This thesis has explored how people engaged in computer-supported cooperation manage to find a balance between working on their individual tasks and taking an active part in work articulation. The special focus has been on the challenges cooperators face in the process and the role of IT as part of the problem but also as a part of the solution.

The challenges associated with modern work contexts have been known for quite some time but, as indicated by current research, cooperators are still struggling to find a balance in their work. The symptoms of this struggle are various forms of overload, work fragmentation, and increased levels of stress (e.g. Dabbish and Kraut 2004, Mark et al. 2005, Janssen and de Poot 2006). The formation of special interest groups (e.g. the Information Overload Research Group[5]), development of computer applications, such as SimpleGTD[6] or ThinkingRock[7]), and increased popularity of RSS, can be seen as indicators

[5] http://www.iorgforum.org/
[6] http://www.simplegtd.com/
[7] http://www.trgtd.com.au/index.php

that researchers and practitioners are not only aware of the challenges, but are also trying to deal with them in a variety of ways.

This work has been guided by a firm belief that it is of central importance to develop an understanding of the foundation on which we design IT-support for the modern work context. With a basis in previous CSCW research and through reliance on a case study research approach and ethnographic data gathering techniques a number of computer-supported work formations active in different contexts have been studied.

The results of these studies show how striking a balance in work is achieved through several balancing acts, and that individuals and groups develop their own strategies in relation to the context of their cooperative activity. Further, the studies show that cooperators take active part in other cooperators' strivings for balance: by managing availability through explicit/implicit means; by regulating disruptive levels of interruptions through taking their own and other cooperators' work context into consideration; by assisting each other in searches for interaction; and by taking into consideration the maintenance of their social networks. Finally, the results show the vital importance of norms, guiding cooperators' behavior, for reducing the levels of interaction needed for work articulation.

Empirical evidence on the challenges associated with striking a balance and the strategies employed by workers in a range of cooperative work formations has been provided. In addition, the main contributions of this work are redefined theoretical concepts (i.e. availability management, interruption, multitasking), an extended understanding of interaction search behavior in social networks, and an understanding of ways to achieve high levels of informal interaction across distance. This work also has practical contributions in the form of implications for designers of supportive IT and implications for cooperators active in modern organizations. Through these contributions the thesis takes a step toward the future, a future in which striking a balance between individual tasks and the coordination of collaborative activities will become increasingly vital.

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